Our Native Ferns And Their Allies.

Underwood.

CARBONIFEROUS PTERIDOPHYTA.—(After Dana.)

OUR NATIVE FERNS

AND

THEIR ALLIES

WITH

Synoptical Descriptions of the American Pteridophyta North of Mexico

BY

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PREFACE.

THE first edition of this manual was published in 1881 and the second in 1882; the continued call for copies of the work is the only apology for a new edition. During the past six years the interest in ferns has largely increased, and has resulted not only in a wider and more thorough study of known forms, but in the less explored portion of our territory new species are continually being brought to light. Of the true ferns (forming the order *Filices*) 140 species were described in the first edition and 145 in the second; in the present edition 156 species are recorded, while three species recognized in former editions have been reduced to varieties.

The Fern Allies are here augmented by the addition of a genus new to this country (*Salvinia*), and five species, two of which are here described for the first time; a reduction of three species has resulted from a more extended study of large suites of specimens, so that 68 species are here recorded.

While the general plan as developed in the former editions has not been greatly modified, the details of the entire work have been thoroughly revised in order that it may be in harmony with the present aspect of structural and systematic study which every year is adding to the sum of our knowledge.

The work is intended as an introduction to the study of ferns and a manual for the easy determination of our species; as such it has aimed to be suggestive in methods of study; to this end the student is referred to the necessary literature, classified according to subjects, at the close of each chapter. It is hoped that the introduction of eight pages of references to the introductory literature of plants lower than the pteridophytes may prove valuable to students who, like the writer, have been obliged to grope in the dark with no kindly suggestion as to what works were valuable for beginners.

Acknowledgments are here rendered to those who have aided in the preparation of this edition. Especially we would mention Dr. Sereno Watson, of the Botanic Gardens at Cambridge for access to numerous specimens; Professor Daniel C. Eaton, of Yale, for elucidating the synonymy of *Aspidium patulum*; and most of all, Mr. George E. Davenport for very many kindly suggestions, specimens, and courtesies extending through a series of years.

Syracuse University,
Feb. 18, 1888.

PREFACE TO FOURTH EDITION.

In the present edition several changes have been made with the purpose of bringing the subject-matter to date. Four additional species have been found in our territory since the last edition was issued, bringing the total number in our flora to 228. Additional matter has been inserted in the text and Chapter VIII has been rewritten in order to bring the classification of the lower plants more in accord with our present knowledge. The most notable change will be found in the nomenclature, which has been revised according to the principles adopted by the American botanists at their meeting at Rochester in August 1892. While many will regret the change of names long familiar, all will see the justice and propriety of the changes. These, however, are not very extensive except in the genus Aspidium, and in this case it will be remembered that the greater part of the species have always been separated by the English botanists under a distinct genus.

De Pauw University,
June 1, 1893.

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INTRODUCTION.

IN the entire vegetable world there are probably no forms of growth that attract more general notice than the Ferns. Delicate in foliage, they are sought for cultivation in conservatories and Wardian cases, and when dried and pressed add to the culture of many a domestic circle by serving as household decorations. They furnish to botanists a broad and inviting field for investigation, and he who examines their more minute structure with the microscope will find deeper and still more mysterious relations than those revealed to the unaided eye. Ferns thus appeal to the scientific element of man's nature as well as to the æsthetic, and while they highly gratify the taste, they furnish food for the intellect in a like degree.

The Fern allies have also played their appointed part in the domestic and decorative economy of this and other generations. The scouring-rushes served our ancestors for keeping white their floors and wooden-ware in the days when carpets were a luxury. The trailing stems of various species of *Lycopodium* have long been valued for holiday decorations ; while their burning spores have flashed in triumphal processions, and have added their glow to the fervor of political campaigns.

In olden time the obscure fructification of the common brake led to many superstitious ideas among the common people, and the older poets have woven these popular notions into our literature. Butler tells in Hudibras of bugbears so often created by mankind :

> "That spring like fern, that infant weed,
> Equivocally without seed,
> And have no possible foundation
> But merely in th' imagination."

Shakespeare only reflects a prevalent belief of his time when he says:

"We have the receipt of fern seed; we walk invisible."

Others allude to the falling of the seed on the anniversary night of the birth of John the Baptist. The old simplers with their lively imagination were impressed by the fancied resemblances of some parts of fern growth to various organs of the human body, and introduced them into their system of specifics. Traces of their influence still remain in the names of some of our common ferns, as spleenwort and maidenhair.

To form a correct understanding of ferns we must study the ferns themselves as well as the text-book, as it is only by direct contact with nature that we gain definite and satisfactory information. The text-book is useful only in giving directions how to investigate. To understand thoroughly an animal we must study its habits in its native haunts. To know its structure and position in the animal kingdom we must carefully dissect a large number of specimens, and study the development of the individual from its beginning. In like manner, to understand fully a fern we must search where nature has planted it, watch it as it uncoils from the bud, matures, produces its fruit, and finally returns to the earth; examine it with needles and lenses, and discover its minute structure and its life-history. These pages, which aim to give an outline of the forms of fern growth, the methods of fruiting, the germination or growth from the spore, and finally the more minute structure of the entire plant, can only be thoroughly understood by taking the ferns in hand and studying them in connection with the text. For the first three chapters and the determination of species a strong pocket lens and a few needles mounted in handles for dissection will furnish the necessary outfit. Chapters IV. and V. will require a compound microscope with its appliances for successful investigation. Those unused to such an instrument will need special directions in regard to the care of a microscope and the methods of using it. Such directions will be found in the laboratory guides recommended in Chapter X. The following will also be useful and suggestive:

STOKES (A. C.). Microscopy for Beginners. 12mo. New York, 1887. (Harper & Brothers.)

BAUSCH (Edward). Manipulation of the Microscope. 12mo. Rochester, N. Y., 1885. (Bausch & Lomb Optical Co.)

A collection of the native ferns of the country is interesting and attractive. Good specimens should include roots so as to show as much as possible of the method of growth. They should be mounted on standard herbarium paper sixteen and one half by eleven and one half inches.

Let no one imagine that the study of ferns will be an easy one. Patient application and careful observation are essential to success, yet he who becomes once interested in the work will find a subject that deepens in interest with every step, and even becomes enchanting as he seeks to determine the mysterious processes of fern development and the marvels of fern structure.

ABBREVIATIONS.

ADANS.....M. Adanson.
AIT.....W. Aiton.
ANGS.....J. Angstrœm.
BEAUV.....P. de Beauvais
BERNH.....J. J. Bernhardi.
BIGEL.....J. Bigelow.
BRACK.....W. D. Brackenridge.
A. BR .....A. Braun.
R. BR.....R. Brown.
BONG .....Bongard.
BRONG.....A. Brongniart.
CAV.....A. J. Cavanilles.
CHAPM .....A. W. Chapman.
DAV.....G. E. Davenport.
DC.....A. P. DeCandolle.
DESF.....R. L. Desfontaines.
DESV.....N. A. Desvaux.
EHRH.....F. Ehrhart.
ENDL.....S. L. Endlicher
ENGELM.....G. Engelmann.
H. & A.....Hooker and Arnott.
H. & G.....Hooker and Greville.
HBK..Humboldt, Bonpland and Kunth.
HITCH.....E. Hitchcock.
HOFFM.....G. F. Hoffman.
HOOK .....W. J. Hooker.
HUDS.....W. Hudson.
HUMB.....Baron von Humboldt
JUSS.....A. L. Jussieu
KAULF.....G. F. Kaulfuss.
KOCH.....W. D. Koch.
KUHL.....Kuhlewein.
L.....C. von Linne [Linnæus].
LAM.....J. B. de Lamarck.
L'HER.....C. L. L'Heritier.
LIEBM.....F. Liebmann.
LINDL.....J. Lindley.
LINN. F.....C. Linnæus (son).
MART. & GALE...Martens and Galeotti.
METT.....G. Mettenius.
MICHX .....A. Michaux.
MUHL.....G. H. E. Muhlenberg.
NECK.....N. J. Necker.
NUTT.....T. Nuttall.
PLUM.....C. Plumier.
REICHENB.....H. G. L. Reichenbach.
RICH.....C. L. M. Richard.
SCHLEICH..... Schleicher.
SCHREB .....J. C. D. Schreber.
SM.....J. E. Smith.
J. SM .....J. Smith.
SPRENG.....K. Sprengel.
SWZ.....O. Swartz.
THUNB.....C. P. Thunberg.
TORR.....J. Torrey.
TUCKERM .....E. Tuckerman.
UNDE .....L. M. Underwood.
VAILL.....S. Vaillant.
VENT.....E. P. Ventenat.
WALL.....N. Wallich.
WALLR .....F. W. Wallroth.
WALT. .....T. Walter.
WILLD.....K. L. Willdenow.

Gr... .....Greek.
Lat.....Latin.
cm... .....centimetre.
mm.....millimetre.
var.....variety.
°.....feet.
′.....inches.
″.....lines.

OUR NATIVE FERNS AND THEIR ALLIES.

CHAPTER I.

HAUNTS AND HABITS OF FERNS.

Our outward life requires them not,—
Then wherefore had they birth?
To minister delight to man,
To beautify the earth.
—MARY HOWITT.

1. **General Characters.**—Our native ferns comprise plants varying in height from less than an inch to six or seven feet, or even more. Some are stout and fleshy, others are delicate and even filmy, but most are herbaceous, resembling ordinary flowering plants in the texture of their foliage. While most would be recognized as ferns by even a novice, a few differ so widely from the ordinary typical forms that to an unskilled observer they would scarcely be considered as bearing any resemblance to ferns whatever. The fronds of one of our Florida species resemble narrow blades of grass, and the fertile spikes of another from New Jersey might be mistaken for a diminutive species of sedge. A third from Alabama would, perhaps, be called a moss by the inexperienced, while the "Hartford fern," found from New England to Kentucky, has a climbing stem and broad palmate leaves.

When we add to these peculiar forms of our own country those of foreign lands, and include the immense tree-ferns of tropical regions, we find our early conception of a fern inadequate to cover this diversity of forms. Without attempting an accurate definition of a fern, let it be regarded for present pur-

poses as a flowerless plant, producing spores instead of seeds, possessing more or less woody tissue, and having its leaves coiled in the bud from apex to base. After the necessary study of the structure of some of our common ferns, we will be able to comprehend the more technical definition found later in the work.

2. **Mode of Growth.**—Ferns vary greatly in their method of growth, yet each species has a plan which, within certain limits, is fixed and definite. Some, like the common brake, have their fronds rising from more or less distant portions of the creeping rootstock. Others, like *Asplenium trichomanes*, are tufted, many fronds rising irregularly in a cluster; while still others, like the ostrich-fern (*Onoclea*) and many of the shield-ferns (*Dryopteris*), grow in crowns or circles, the later fronds continually rising within the older ones. In the grape-ferns (*Botrychium*) the rootstocks usually produce a single frond each season, the bud for the succeeding year growing within the base of the common stalk.

3. In many there is a tendency to dimorphism, the fertile or fruit-bearing fronds differing to a greater or less extent from the sterile ones. In a few species, like the sensitive-fern and the ostrich-fern (*Onoclea*), this is carried so far that the sterile and fertile fronds bear no resemblance to each other, and in one instance have been mistaken for different species, and so described. *Osmunda cinnamomea*, *Woodwardia areolata*, *Pellæa gracilis*, *Cryptogramme*, and *Lomaria* offer further examples of this principle of growth.

4. **Variation.**—The same species will often present wide differences in the size of the fronds. This depends to some extent on the character of the soil and the ordinary climatic conditions. For example, the lady-fern (*Asplenium filix-fœmina*), which in ordinary locations grows from two to four feet high, in mountainous regions is sometimes reduced to from three to six inches, when it forms the *var. exile*. In like manner the marginal shield-fern (*Dryopteris marginalis*), usually two or three feet high, is reduced to five inches when growing on rocky cliffs, and yet regularly produces fruit.*

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* *Cf.* Bulletin Torrey Botanical Club, VI. 266 (Oct. 1878).

5. In some cases there is a tendency to variation in size that cannot be referred to soil or climatic influences. The common grape-fern (*Botrychium Virginianum*) will be found in some localities to vary from six inches to two feet in height, all well fruited and matured, and with the extreme sizes growing within a pace of each other in the same soil and with the same environment. The other species of the same genus present similar variations, and judging from size and external appearance alone, a regular gradation of forms might be arranged from the most diminutive undivided forms of *B. simplex* to the largest of *B. Virginianum*.

6. Another tendency to variation is noticed in the forking of fronds either at the summit or at the ends of the branches. The hart's-tongue (*Scolopendrium*) is frequently forked at the summit, the walking-leaf (*Camptosorus*) less commonly, while the same tendency is noticed in various compound forms, as *Asplenium angustifolium*, *Cheilanthes vestita*, *Gymnogramme Ehrenbergiana*, *Dicksonia*, *Pellæa atropurpurea*, and others. Some of the species of *Botrychium* show the same tendency, especially in their fertile segments. It is probable that all our species will be found to fork under certain conditions. More definite information is desirable with regard to many species that show this tendency, as it doubtless involves the question of ancestry of existing ferns.

7. In those species whose sterile and fertile fronds are unlike, forms often appear that are intermediate between the sterile and fertile fronds, and sometimes even form a graded series from one to the other. This is especially true of the sensitive-fern (*Onoclea*) and the cinnamon-fern (*Osmunda cinnamomea*), and has frequently been the source of so-called "varieties." Whether this variation arises from some peculiarity of environment, or from some inherent tendency to reversion toward an older form, will require more extended observation to determine. One of the varieties of *Botrychium ternatum* seems to have been founded on a condition which is intermediate in structure between the sterile and fertile segments.

8. In a few forms there is an apparent mimicry, one species imitating another in foliage or method of fruiting. In the cinnamon-fern just alluded to, which has a cinnamon-colored

sterile frond totally unlike the fertile, sterile fronds will sometimes be found which are fertile at the apex—the normal method of fruiting in the royal flowering-fern (*Osmunda regalis*); and in turn the royal flowering-fern is sometimes fertile in the middle, in imitation of *Osmunda Claytoniana*.

9. **Time of Fruiting.**—The time of maturing fruit is different among different species, and also varies with geographical location and proximity to tropical climates. In the Northern States some species produce their fruit as early as May (*Osmunda cinnamomea*), and others as late as September (*Lygodium*), but the greater number are best studied in July and August. In the Northeastern States, where the two species of *Cystopteris* abound on limestone rocks, *C. fragilis* matures its spores and withers in June or July, while *C. bulbifera* reaches its maturity only in August or September. In semi-tropical climates, like Southern California and the Gulf States, the time of fruiting is often earlier, sometimes occurring in February or March. Some fronds are killed by the early frosts, while others, like the Christmas-fern, are evergreen, and may be gathered in midwinter.

10. **Local Distribution.**—Ferns are largely dependent for successful growth on the amount of warmth, moisture, and shade to which they are subjected, and we would naturally expect to find them reaching a maximum in size and abundance in warm swamps or shady marshes. While this is in general true, we nevertheless find many species thriving only in rocky places, thrusting their roots into the crevices of the rocks with little earth for their nourishment, and many times exposed to the scorching rays of the sun. Of necessity, such species are comparatively small size, and likely to be protected in some way against the heat of the sun, and provided with means to retain their moisture in times of drought. Others still are found in wet, rocky ravines, often where moistened by the spray of cascades or waterfalls, and consequently have no such provision against the heat of an extended summer. Certain others thrive in open fields that are comparatively dry and unshaded. One species of Southern Florida is aquatic, having the sterile fronds floating in shallow water. A few species are epiphytic, or grow on other plants, some being found on tree-trunks to the height of 150 or 200 feet!

So, while moisture, warmth, and shade in abundance are the climatic conditions essential to promote luxuriant fern growth, it can and does continue when any or all these conditions are reduced to a minimum.

11. Ferns may then be sought in any of the following situations, and it will be seen that each situation has its characteristic species:

A. Wet swamps or marshes with or without abundant shade.

B. Rich woods, more or less moist.

C. Uncultivated open places and dry hillsides.

D. Moist, rocky ravines or rocky places not subject to summer drought.

E. Exposed rocky cliffs.

F. Standing water.

G. Growing on other plants. (Epiphytic.)

12. In the first location mentioned above, we may find the chain-ferns (*Woodwardia*), many of the spleenworts (*Asplenium*), a few of the shield-ferns (*Dryopteris*), the flowering-ferns (*Osmunda*), as well as the genera *Acrostichum, Onoclea*, etc. These include some of our largest and coarsest ferns. A few more delicate in structure are also found here, notably the dainty *Phegopteris dryopteris.*

13. In the second we find a few spleenworts, most of the shield-ferns, the beech-ferns (*Phegopteris*), most of the grape-ferns (*Botrychium*), the maidenhair (*Adiantum*), the *Dicksonia*, and some others. In this situation we find the finest development of foliage and the greatest artistic finish among all the ferns.

14. In uncultivated places and on rocky hillsides we often find the common bracken or brake (*Pteris aquilina*), and the lady-fern (*Asplenium filix-fœmina*), though these are by no means confined to these locations, the latter growing quite frequently in moist woods, and even in cold, wet swamps. Many other ferns are found occasionally in openings of the forest or recent clearings, where they maintain a sickly existence, sometimes for a series of years. In such locations ferns often become contracted and abnormal in growth, and take on a faded yellow hue from their exposure to the open sunshine.

15. In moist ravines and on rocky banks the bladder-ferns (*Cystopteris*) may be found, with the peculiar walking-leaf

(*Camptosorus*), the rare hart's-tongue (*Scolopendrium*),* and many of the smaller spleenworts. The long, pendent fronds of *Cystopteris bulbifera* add greatly to the beauty of our natural ravines, and often serve to conceal the uncouth rocks, or at least draw the attention to that which is more delicate and artistic. On dripping rocks, or where the sides of ravines are kept continually moist by the spray of waterfalls, such delicate pellucid ferns as the filmy-fern (*Trichomanes*) and *Pellæa gracilis* may be sought. There seems to be a direct connection between the environment and the texture of the fern. The last two mentioned grow in very damp situations, and are pellucid and almost membranous. *Cystopteris* in somewhat drier situations is thinly herbaceous, while *Asplenium trichomanes* and *Camptosorus*, requiring less moisture, are more firm, and form the transition to the next group.

16. On dry cliffs we may look for the various species of *Woodsia*, the cloak-ferns (*Notholæna*), the lip-ferns (*Cheilanthes*), and the cliff-brakes (*Pellæa*). Many of these are firm and even leathery in texture, and others are thickly covered on one or both sides with tangled hair or scales, fitting them to survive long periods of drought.

17. Only one of our native species is strictly aquatic, the anomalous *Ceratopteris thalictroides* found in Southern Florida, though *Acrostichum aureum* is often found with its rhizoma rising from the water of salt marshes. *Osmunda regalis* is occasionally found in standing water several inches deep, though this is not usual.

18. Among the epiphytic ferns are several species of *Polypodium*, *P. polypodioides*, *P. Scouleri*, and *P. aureum*, the last always being associated with the cabbage-palmetto (*Sabal palmetto*). *Vittaria*, *Tænitis*, and *Nephrolepis* are also of this class, and are frequently pendent from the same plant, though occasionally found on other tree-trunks. *Ophioglossum palmatum*, another peculiar tropical fern-ally, belongs to the same

* This rare fern seems to show a decided preference for limestone rocks, and thus far has been found only above the geological formation known as the Corniferous limestone. I believe a thorough search for this fern along the outcrops of the formation in Central New York and elsewhere would show a wider distribution than is at present attributed to this species.

list. Even in the streets of Southern cities, *Polypodium polypodioides* is often seen growing with various mosses well up on the trunks of shade-trees. It is only in tropical regions, however, that epiphytes are seen in profusion.

19. These principles of climatic distribution are necessarily modified by the geographic range of species, which must be considered in this connection. For example, *Dryopteris spinulosa* or its varieties form the leading foliage ferns of Northern New England and New York, while *Dicksonia*, less common in those localities, largely replaces them from Connecticut southward. This subject will be more fully discussed in a later chapter.

LITERATURE.

Most of the American literature bearing on this subject is in the form of short notes which have appeared from time to time in our two botanical monthlies;* a classified summary appears below:

HABITS.—*Botanical Gazette*, I, 2; II, 100; III, 82; IV, 140, 177, 232; V, 27, 30, 43, 48; VI, 161, 295; VII, 86.

DIMORPHISM.—*Torrey Bulletin*, VIII, 101, 109; IX, 6; XIII, 62.

FORKING FRONDS.—*Botanical Gazette*, I, 50; II, 80; III, 39; VI, 220; VIII, 242.—*Torrey Bulletin*, VII, 26, 85; IX, 116, 129; X, 4.

RELATIVE ABUNDANCE:—

DAVENPORT (George E.). A Bit of Fern History. In *Botanical Gazette*, VII, 60–64 (May, 1882).

CULTIVATION:—

JACKSON (Robert T.). Cultivation of Native Ferns. In *Garden and Forest*, I, 317, 318; 330, 331; 340–342; 352–354 (Aug.-Sept. 1888).

ROBINSON (John). Ferns in their Homes and Ours. 12mo, illustrated. Salem, 1878. A valuable outline of fern cultivation, indispensable to those desiring to undertake the cultivation of ferns either in conservatories or Wardian cases.

SMITH (John). Ferns, British and Foreign, 8vo. London, 1879.

* The *Botanical Gazette* (Bloomington, Ind.) and the *Bulletin of the Torrey Botanical Club* (Columbia College, New York). Students of ferns should have these journals on file to enable them to appreciate the botanical activity of the country.

CHAPTER II.

THE ORGANS OF THE GROWING FERN.

Pour bien savoir une chose, il faut en savoir les details.
—La Rochefoucauld.

20. Every one familiar with the forest and its products must have seen the young ferns unrolling from the bud in spring and early summer. It will be noticed that the fronds are coiled from the apex to the base, and form crosiers, so called from their resemblance to the head of a bishop's staff. This method of vernation is called *circinate*, and is rarely found except among ferns. In the grape-ferns and adder-tongues the vernation is straight or merely inclined, thus approximating that of ordinary flowering plants.

21. **Rootstock.**—Ferns usually spring from an underground stem called the *rootstock*. This may be simple or branched, smooth or scaly, horizontal, oblique, or even vertical. In some ferns it is fine and hairlike, while in others it is very large and stout. In some cases the rootstock creeps at the surface of the ground and even rises above it, as in the variety of *Dryopteris contermina* which grows in Florida. In the tree ferns of warmer climates it often forms a trunk fifty feet high, bearing the fronds at the summit, when it takes the name of *caudex*.

22. **Frond.**—The aerial portion consists essentially of a leaf-stalk and blade; the former is technically called the *stipe*, and the latter the *frond*. Though these are usually distinct from each other in appearance, the stipe is sometimes wanting, and in others no distinction can be made between them. Both stipe and frond, or either one, may be glabrous (smooth), pubescent (softly hairy), hairy, woolly, or scaly; when the scales are small and somewhat appressed, the surface is said to be squamous. The careful discrimination of these hairy or scaly appendages becomes a matter of importance in distinguishing many of the species of *Cheilanthes*. In a few of our native ferns

the under surface is covered with a white or yellow powder bearing some resemblance to flour or corn-starch. For this reason a surface of this character is called *farinaceous*. Such is the California gold-fern or "golden back" (*Gymnogramme triangularis*), and several of the cloak-ferns (*Notholæna*), and such are the various gold and silver ferns of conservatories, including some of the richest and most beautiful in the world.

23. The frond may be *simple*, when it consists of a single undivided leaf, as in *Scolopendrium* or *Camptosorus*; or *compound*, when it is divided into segments. The exquisite delicacy and the extent to which this dividing is carried in some ferns determines largely their æsthetic value.

The continuation of the stipe through a simple frond is called the *midvein*; through a compound frond is called the *rachis*, and is further distinguished as *primary* when the frond is much compounded. A frond is *entire* when the margin forms an unbroken line; when so cut as to form lobes extending half way or more to the midvein it is called *pinnatifid*; when these incisions extend fully to the midvein the frond is said to be *simply pinnate*, and the divisions are called *pinnæ*. When the pinnæ are cut into lobes the frond is *bipinnatifid* and the lobes are called *segments*, and when these extend to the secondary midveins it is *bipinnate* and the divisions are called *pinnules*. The secondary midvein then becomes a *secondary rachis*. In like manner we may have ferns that are *tripinnatifid* and *tripinnate*, *quadripinnatifid* and *quadripinnate*. The last lobes are designated *ultimate segments*, and the last complete divisions *ultimate pinnules*. All these various forms from entire to quadripinnate are abundantly represented among our native ferns.

24. In some pinnate fronds, as in the oak-fern (*Phegopteris dryopteris*), the lower pair of pinnæ is greatly enlarged and more compound than those above, so that the stipe appears to form three branches bearing similar and nearly equal portions. Fronds of this character are usually triangular or pentagonal in outline, and this method of branching is called *ternate*. It will be readily seen that this is merely a modified form of the ordinary pinnate frond. Throughout the domain of nature there is infinite variety of form and structure, and at the same time unity in plan and conformity to a few generalized types.

25. **Venation.**—The method of veining admits of great variation, often serving to distinguish species, and more especially the sections of the various genera. In some ferns, like most shield-ferns (*Dryopteris*), the veins are *free*—that is, arising from either side of the midvein they do not unite with any other vein. In some of these the vein is simple (not branched), in others variously forked. In many the veins repeatedly anastomose or unite together, forming a series of network or *areolæ*. This may be somewhat irregular, as in *Onoclea;* or forming a single row of areolæ next to the midvein and thence free to the margin, as in *Woodwardia Virginica;* or forming many uniform areolæ by the parallel transverse veinlets connecting the distinct and parallel primary veins, as in *Polypodium phyllitidis*. In case the venation does not appear when examined by reflected light, it may be brought out clearly by holding the frond between the observer and the light, and then using a lens if necessary. A few fleshy species require dissection to show the veins.

CHAPTER III.

FRUCTIFICATION IN FERNS.

"But on St. John's mysterious night,
Sacred to many a wizard spell,
The hour when first to human sight
Confest, the mystic fern-seed fell."

26. **Spores and Sporangia.**—In the flowering plants (SPERMAPHYTES) there is a manifest sexual reproduction, the ovules in the female organs (pistils) being fertilized by the pollen produced by the stamens, thus giving rise to the embryo of the new plant. The Ferns, on the contrary, produce no flowers. Instead of seeds developed from fertilized ovules, minute spores are produced asexually, from which new ferns are developed by a peculiar process of germination very unlike that

FIG. 1.—Enlarged section through a sorus of *Polypodium falcatum* Kellogg, showing the stalked sporangia.

of flowering plants. These spores are collected in little sacs known as *sporangia* or spore cases. The sporangia in the true ferns (POLYPODIACEÆ) are collected in little clusters on the back of the frond, or are variously arranged in lines along the veins or around the margins (Fig. 1). These clusters of sporangia are called *sori*, and may be naked, as in *Polypodium*, or provided with a special covering known as the *indusium*, as in *Dryopteris* (Fig. 8). The various forms of the sori and indusia serve as the basis for classification into genera and tribes, while each sub-order has its peculiar form of sporangia.

FIG. 2.—Sporangium of *Polypodium vulgare*, L., discharging its spores. Much enlarged.

27. In the POLYPODIACEÆ the sporangia are more or less completely surrounded with a jointed vertical ring or *annulus*, and at maturity burst open transversely by the straightening of the annulus and discharge their copious spores (Fig. 2). The clusters of sporangia are said to be marginal, intramarginal, or dorsal, according as they have their position at the margin or more or less remote from it. They may be roundish, oblong, or linear in shape, or arranged in variously forking lines, or may even be spread in a stratum over the entire under surface of the frond. They are called indusiate or non-indusiate according as they are covered or naked; and the indusia may be inferior (attached below the sorus), as in *Woodsia* (Fig. 9), or superior, as in *Dryopteris* (Fig. 8), or of various intermediate methods of attachment.

28. In the other sub-orders of FILICES the sporangia are variously arranged. In the HYMENOPHYLLACEÆ or filmy ferns the flattened sporangia are sessile along a filiform receptacle, and are surrounded with a complete transverse annulus. At maturity they open vertically (Fig. 3). In the SCHIZÆACEÆ the sporangia

FIG. 3.

FIG. 4.

Fig. 3.—Enlarged sessile sporangium of *Trichomanes radicans* SW.

Fig. 4.—Sporangium of *Schizæa pusilla* Pursh, showing the apical ring. Much enlarged.

are ovate, surrounded at the apex by a complete annulus, and open by a longitudinal slit (Fig. 4). In the OSMUNDACEÆ or flowering ferns the sporangia are larger, globose, and naked, with the mere trace of a transverse annulus, and open longitudinally.

The various methods of fructification can be best understood by describing the peculiarities of the various genera in regular succession and noting the variations occurring in the sections or sub-genera. By this means we will arrive at a better understanding of the principles of fern classification as discussed in a future chapter. As the subject of venation is closely connected with that of fructification, it will be treated in the same connection.

29. **Acrostichum.**—In this genus the sporangia are spread in a stratum over the under surface of the upper pinnæ in our solitary species, but in some exotics they cover portions of the upper surface as well. There is no indusium.

30. **Polypodium** (Fig. 1).—This genus contains the largest number of existing ferns, and though all the species agree in the roundish naked sori, the venation is widely different in the various sections, which are chiefly formed on the character of the veins. Four of the five sections are represented in our nine species.

In § EUPOLYPODIUM the veins are free, yet are occasionally known to unite,* thus indicating a tendency to vary toward the next section. The sori are generally found at the end of a free veinlet.

In § GONIOPHLEBIUM the veins unite near the margin, forming large areolæ, each containing a single free veinlet which bears the sorus at its end. A tendency to variation is seen in *P. polypodioides*, whose veins are free, as well as in *P. Californicum* in which they are often partly free.

In § PHLEBODIUM the veins form ample areolæ in a row next the midvein, and frequently in one or more secondary rows, each bearing a single sorus at the junction of two or more veinlets. A large number, however, bear the sori at the end of a single veinlet. From the fertile areolæ to the margin the veins anastomose more copiously.

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* Catalogue of the Davenport Herbarium, p. 8.

In § CAMPYLONEURON the areolæ, each usually bearing two sori, are found between the parallel primary veins which extend from the midrib to the margin.

31. Gymnogramme.—In this genus the sori follow the course of the veins, and consequently vary with the venation, being simple, forked, pinnated, or anastomose with each other. The sori are non-indusiate.

32. Notholæna.—In the cloak-ferns the sori are marginal, and provided with no indusia. This genus is linked very closely to *Gymnogramme* on one hand and to some species of *Cheilanthes* on the other. From the latter it is separable only by the absence of the marginal indusium; the two are likely to be confounded by beginners.

33. Tænitis has simple fronds, and the fructification in a continuous sub-marginal line near the apex of the frond.

34. Vittaria.—This peculiar genus occupies a somewhat intermediate position between the indusiate and non-indusiate genera, and while usually associated with the latter has considerable claim to be ranked with the former. The fronds are narrow and grass like, bearing the sporangia in an intramarginal groove, often more or less covered by the inrolled edge of the frond. The venation is very obscure.

35. Adiantum (Fig. 5).—The maidenhairs have a peculiarly smooth foliage, and usually possess no midvein. The veins are usually flabellate, and after forking one or more times bear the sori at their extremities. The margin of the frond is reflexed, thus forming an indusium which bears the sporangia on its under surface.

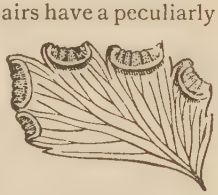


FIG. 5.—A segment of *Adiantum*, showing the sori covered by indusia formed by reflexions of the margin of the frond.—From Le Maout and Decaisne.

36. Pteris (Fig. 6).—In this genus, which includes the common brake, the otherwise free veins are united by a filiform receptacle which bears the sporangia. This continuous marginal line of fructification is covered by a membranous indusium formed of the margin of the frond.

37. Cheilanthes.—The lip-ferns found within our limits are unequally divided among four sections, all agreeing in bear-

ing the sori at or near the ends of the veins, covered by an indusium formed of the margin of the frond.

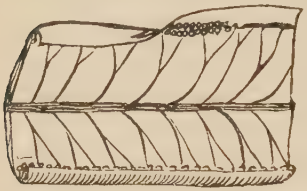


FIG. 6.—*Pteris longifolia* L. Enlarged segment of pinna, showing the vein-like receptacle under the marginal indusium.

In § ADIANTOPSIS the indusia are distinct, and confined to a single veinlet. One of our species varies from the typical species of this section, and has even been assigned to a separate genus.

In § EUCHEILANTHES the indusia are more or less confluent but not continuous, usually extending over the apices of several veinlets.

In § PHYSAPTERIS the ultimate segments are bead-like, and the indusium is continuous all round the margin.

§ ALEURITOPTERIS has the fronds farinose below, and includes a single species somewhat doubtfully assigned to our limits.

38. Cryptogramme has dimorphous fronds, the margins of the fertile being closely rolled toward the midvein, thus covering the confluent sori. At maturity these open flat in order to discharge the spores.

39. Pellæa has representatives of three sections within our limits, all agreeing in possessing intramarginal sori, which finally became confluent and form a marginal line covered by an indusium formed of the margin of the frond.

§ CHEILOPLECTON includes herbaceous species with visible veins and broad indusia.

§ ALLOSORUS includes coriaceous species having wide indusia, while § PLATYLOMA includes species similar in texture, but with extremely narrow indusia and broad segments.

40. Ceratopteris is an anomalous genus from southern Florida, having a few sori arranged on two or three veins parallel to the midvein, and covered by the broadly reflexed margin of the frond.

41. Lomaria (Fig. 7) stands intermediate between those genera, in which there is an indusium formed of the revolute margin of the frond and those in which the indusium is remote from the margin. Our single species has dimorphous fronds, free veins, and the fructification in a broad band next the mid-

vein, covered by a continuous and distinctly intramarginal indusium. This genus closely resembles the next in general habit, and is sometimes united with it.

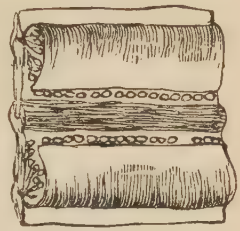


FIG. 7.—*Lomaria spicant* Desv. Enlarged section of the contracted fertile pinna, showing intramarginal indusium.

42. Blechnum.—In this genus the sori are linear and near the midvein, and are covered by a membranous indusium which is fixed at its outer margin, bursting at its inner margin when the sporangia are mature. A single representative is found within our limits.

43. Woodwardia.—Three species of chain-ferns occur within our limits, and each represents a distinct section based on the methods of venation. All have oblong or linear sori more or less sunken in the frond, covered by special lid-like indusia bursting at their inner margins, and arranged in chainlike rows near the midvein, thus giving the popular name to the genus.

§ EUWOODWARDIA has uniform fronds and veins forming at least one series of areolæ between the sori and the margin.

§ ANCHISTEA has also uniform fronds, but with free veins from the sori to the margin while § LORINSERIA has dimorphous fronds, and the veins everywhere uniting to form areolæ, as in the sensitive-fern (*Onoclea sensibilis*).

44. Asplenium.—The numerous species of spleenworts are closely related to each other in their methods of fructification, but differ widely in the form, texture, and cutting of their fronds. The sori are placed on the upper side of an oblique vein (sometimes crossing it in § ATHYRIUM), and covered by an indusium of the same shape attached by its edge to the fruiting vein and opening toward the midvein. In some species part of the indusia are double. The veins are free in all our species. In § EUASPLENIUM the sori are straight or slightly curved; in § ATHYRIUM they are often curved, even horseshoe shaped; and frequently cross to the outer side of the fruiting vein.

45. Scolopendrium bears the linear sori in pairs, one from the upper side of a veinlet and its mate from the lower side of the next. The indusia are attached by their edges to the veins, and folding toward each other appear like a double

indusium covering a single sorus. The veins extend nearly at right angles to the midvein, are free, and usually forked.

46. Camptosorus.—The walking-leaf has oblong or linear indusiate sori, which are irregularly scattered and borne partly on veins parallel to the midvein, and partly on those that are oblique. Those near the midvein are single, those toward the margin are often approximate in pairs and often form crooked lines. The veins are everywhere copiously reticulated.

47. Phegopteris.—In this genus the sori are round and naked as in *Polypodium*, with which this genus is sometimes united. The sporangia spring from the back of the veins instead of the apex, as in the latter genus, and the veins are free except in the § GONIOPTERIS, in which they are more or less united.

48. Dryopteris is largely represented in our limits by two well-marked sections, which are sometimes regarded as distinct genera, and two others with characters scarcely less distinct, containing each a single species. In all the sori are roundish, and borne on the back of the veins or rarely at their apex. In § NEPHRODIUM the indusium is cordato-reniform or orbicular with a narrow sinus. This at first covers the sorus and is attached by its margin, but later bursts away at the margin but remains attached at the sinus. In some species in this section the indusium becomes shrivelled before the fruit matures, and in this condition might be mistaken for a non-indusiate species (Fig. 8).

FIG. 8. — Under side of a fertile segment of *Dryopteris filix-mas*, with eight sori. *i*, the indusium. Magnified. (After Sachs.)

In § POLYSTICHUM the indusium is orbicular and peltate, being fixed by the centre; the veins are free, as in § NEPHRODIUM.

In § CYRTOMIUM the indusium is the same as in § POLYSTICHUM, but the veins tend to unite near the margin, while in § ASPIDIUM the veins anastomose copiously.

49. Nephrolepis has roundish sori borne at the apex of the upper branch of a free vein, near the margin of the frond. The indusia are usually reniform, fixed by the sinus or base, and open toward the margins of the pinnæ.

50. Cystopteris.—The bladder-ferns take their popular

name from the delicate, hood-like indusium which is attached by its broad base on the inner side of the roundish sorus and partly under it. Later this is thrown back and withers away. The veins are free, and the fronds have the aspect of species of *Dryopteris*, but are usually more delicate in texture.

51. Onoclea.—This genus contains two quite dissimilar species, which until recently have been separated into two genera by American botanists. Both have dimorphous fronds, the margin of the contracted fertile frond being strongly revolute, and concealing the fruit. *O. struthiopteris* has necklace-shaped pinnæ, crowded confluent sori, and free and simple veins. *O. sensibilis* has panicled berry-shaped pinnules and copiously anastomosing veins.

52. Woodsia (Fig. 9) has roundish sori borne on the back of the veins, with the indusia attached beneath the sporangia and flat and open, or early bursting at the top into irregular laciniæ or lobes. In § EUWOODSIA the indusia are flat and open from an early stage, with their cleft and ciliate margins concealed under the sori. In § HYPOPELTIS the indusium is more conspicuous and encloses the sporangium at first, but soon bursts at the top, forming several jagged lobes.

FIG. 9.—*Woodsia obtusa* Torr. Enlarged section of pinnule, showing venation and inferior indusia.

53. Dicksonia.—In this genus the small globular sorus is borne in an elevated, globular receptacle, and enclosed in an inferior, membranous, cup-shaped indusium. The veins are always free.

54. Trichomanes (Fig. 10) has sessile sporangia borne on a filiform receptacle at the summit of a vein. The indusia are tubular or funnel-shaped, with an expanded and often somewhat two-lipped mouth.

FIG. 10.—*Trichomanes radicans* Swz. Enlarged section, showing method of fructification.

55. Lygodium.—In our species of climbing-fern the fructification is borne on contracted, forked pinnules occupying the upper portion of the frond. The ovoid sporangia are solitary or occasionally in

pairs, and are borne in the axils of the large, imbricated, scale-like indusia which are fixed by their bases to short, oblique veinlets.

56. Aneimia.—In this genus the two lowest branches of the frond bear panicles of fruit at the end of very long stalks. The ovate sporangia are sessile in two rows along the branchlets of the panicle, without special covering of any kind. In the section represented by our species the veins are free.

Fig. 11.—*Schizæa pusilla* Pursh. Entire plant, natural size.

57. Schizæa.—In this genus the large ovoid sporangia are sessile in double rows along the single vein of the narrow fertile divisions. In our species the pairs of fertile pinnæ form a distichous spike (Fig. 11).

58. Osmunda has the large globose sporangia, short-stalked, and borne on the contracted fertile portions of the frond. In the cinnamon-fern (*O. cinnamomea*) the fertile fronds are entirely distinct from the sterile, yet manifesting a tendency to variation in the *var. frondosa*. In the interrupted flowering-fern (*O. Claytoniana*) the fructification is confined to a few of the middle pinnæ of the frond. In the royal flowering-fern (*O. regalis*) the fructification is borne at the apex of the fronds.

59. Spores.—The spores of ferns constitute the fruit proper. A spore consists of two* distinct closed sacs and the cell contents, all of which differ from each other not only in structure, but also in chemical composition. The outer layer (*exospore*) consists chiefly of cellulose; the inner layer (*endospore*) contains some albuminous matter in addition, while the cell contents consist chiefly of a thin, colorless, jelly-like substance known as protoplasm, with grains of chlorophyll (the green

* Campbell has recently demonstrated the existence of a third (middle) layer, which is not readily apparent until after germination. *Cf.* Memoirs Boston Soc. Nat. History, IV, 17 *et seq.* (April, 1887).

coloring matter of plants), starch, and oil. The exospore may be smooth or roughened by points, granules, warts, or prickles. The shape varies with different species, yet all are rounded, and most are oblong or at least longer than broad. All are microscopic, and many are of such a shape that they do not appear uniform owing to the various directions from which we view them.

60. The number of spores produced by a single fern is incredible. Lindley calculated that a single frond of *Scolopendrium* produced about 80 sori, with an average of 4500 sporangia in each sorus, and each sporangium containing 50 spores, making a total of 18,000,000 spores. The copious green spores of *Osmunda cinnamomea*, or the pale-yellow, powdery spores of a well-developed specimen of *Botrychium Virginianum*, must far exceed this computation. By drying either of these species under pressure between sheets of paper great quantities of the spores may be obtained for examination. Specimens for this purpose should be selected just before the sporangia reach their maturity.

CHAPTER IV.

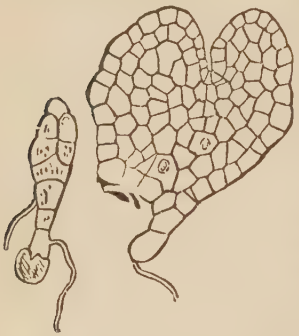
GERMINATION OF FERN SPORES.

Alle Glieder bilden sich aus nach ew'gen Gesetzen,
Und die seltenste Form bewahrt im Geheimniss das Urbild.
—GOETHE.

61. THE germination of the fern spores usually takes place a considerable time after they are discharged from the sporangia, but in *Osmunda*, which develops its fruit early in the season, they commence their growth only a few days after dissemination.

62. **Thalloid Phase.**—In germination the exospore splits along the side, and the protruding endospore, sometimes with its divisions already formed by septa or partitions, forms, not a fern, but a thalloid structure resembling one of the lower

liverworts called the *prothallium*. Different ferns vary in the method of forming this prothallium, some producing it immediately at the spore and others after the formation of a thread-like growth known as the pro-embryo. The prothallium is entirely composed of cellular tissue, and in the true ferns (POLYPODIACEÆ) is broadly cordate or reniform in shape, and bears large numbers of root-hairs from the under part of its posterior portion (Figs. 12, 13).



FIGS. 12, 13.—Prothallium of *Pteris serrulata* Linn. f., showing two stages of growth. (After Moore.)

The prothallium varies in size from less than one tenth of an inch up to one third of an inch in its widest part. On the under surface of the prothallium two sorts of organs are produced analogous to the stamens and pistils of the SPERMAPHYTES, respectively known as *antheridia* and *archegonia*. The position of these organs on the prothallium varies in different sub orders. In some species, notably the ostrich-fern, the two kinds of sexual organs are produced on separate prothallia, so that the plant becomes diœcious instead of monœcious. Analogous cases are familiar to all among flowering plants like the willows, poplars, and box elders (diœcious), and begonias and melons (monœcious).

63. Antheridia.—These are small masses of tissue developed in the same manner as the root-hairs, consisting of a single layer of cells forming the wall, and containing a number of spirally coiled threads, usually with a number of cilia on their anterior coils. At maturity the antheridium swells by the absorption of water and finally bursts its wall, discharging these coiled filaments, which possess the power of locomotion, and for this reason are called *antherozoids*. These antherozoids often drag with them a little vesicle which seems to play no part in the process of reproduction (Fig. 14).

64. Archegonia.—The archegonium (sometimes called pistillidium) is also a rounded mass of tissue usually less prom-

inent than the antheridia, consisting of an external layer of cells and a large central cell, which soon divides into two. The lower portion, at first the larger, develops into a roundish cell, which is analogous to the ovule of flowering plants, and is called the *oösphere*. The upper portion of the central cell develops between those composing the neck of the archegonium into a canal filled with a sort of mucilage; this finally swells up, forces the cells of the neck apart, and is expelled to aid in attracting

FIG. 14.—Antheridium of *Adiantum capillus-veneris* L., showing the escaping antherozoids. (After Sachs.)

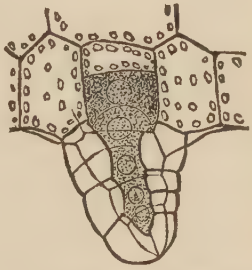


FIG. 15.—Young archegonium of *Pteris serrulata* Linn. f., showing oösphere, neck, and canal-cell. (After Sachs.)

and retaining the antherozoids at the neck of the archegonium. The oösphere is thus left exposed (Fig. 15).

65. Fertilization.—The antherozoids, analogous to the pollen of flowers, when discharged from the antheridium swim in the moisture always present on the under surface of the prothallium, swarm in large numbers around the neck of the archegonium, and are retained by the mucilage. Some finally force their way into the canal of the neck, a few reaching the oösphere and disappearing within its substance. There is thus a true sexual generation among ferns, and the formerly appropriate term *Cryptogamia* (hidden marriage) loses its application under the untiring scrutiny of the microscopist. After fertilization the neck of the archegonium closes, and the fertilized

oösphere, now called the *oöspore*, increases in size, and finally develops into a true fern.

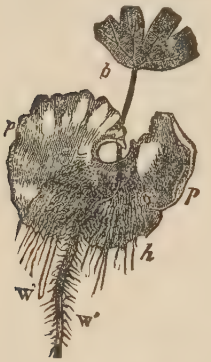


FIG. 16. — *Adiantum capillus-veneris* L. Prothallium and young fern seen from below; *pp*, prothallium; *b*, first leaf; *h*, root-hairs of prothallium; *w*, *w'*, first and second roots. (After Sachs.)

66. Pteridoid Phase.—After the oösphere has been fertilized it commences its growth by the ordinary processes of cell multiplication, and for a time remains within the walls of the archegonium, which continue to grow, until finally the interior growth breaks through the walls, differentiated into its first root and leaf. The young fern draws its nourishment from the prothallium for a time, but soon develops root-hairs, which, extending into the soil, maintain thereby an existence independent of the prothallium. The latter growth having accomplished its work, withers away (Fig. 16). The first parts of the root, stem, and frond are very small and comparatively simple in structure, but those formed later are successively larger, and not only bear a closer resemblance to the mature form of the species, but also develop increased complexity of structure. "The fern continues to gain strength, not by subsequent increase of size of the embryonic structures, but by each successive part attaining a more considerable size and development than the preceding ones, until at length a kind of stationary condition is arrived at, in which the newly formed organs are nearly similar to the preceding ones."

67. The complete life-history of a fern illustrates a principle common among the lower forms of animal life known as "alternation of generations." Instead of the direct production of a mature sexual plant, as among the higher forms of vegetation, there is the production of a sexual growth resembling a lower form of vegetation, which in turn is followed by the growth of a mature plant producing its fruit without the assistance of sexual organs.

68. Recapitulation.—To review the life-history of a fern we find the following processes:

A. Production of the spores asexually by the mature plant. (FRUCTIFICATION.)

B. Growth of the prothallium from the spore with or without the development of a pro-embryo. (THALLOID PHASE.)*

C. Production of sexual organs, archegonia (female) and antheridia (male), on the under surface of the prothallium, or on separate prothallia.

D. Fecundation of the oösphere developed in the archegonium by the antherozoids developed in the antheridium. (FERTILIZATION.)

E. Growth of the mature fern in successive stages from the oöspore. (PTERIDOID PHASE.)*

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* The terms "Thalloid Phase" and "Pteridoid Phase" in place of the older terms "sexual generation" and "asexual generation" were first suggested in the first edition of this work (1881). The older terms, although in common use by botanical writers, are decidedly unfortunate and misleading. A generation is properly the production of offspring resembling the parent, or the offspring thus produced, which the prothallium is not and the mature fern is not. The generation proper must then be considered as including the entire life-history of a fern, of which the prothallium and mature fern are successive phases. The terms "sexual" and "asexual" as used in this connection are likewise misleading, as they might apply as well to the origin as to the producing power of the so-called "generation." The prothallium is asexual in origin, but develops sexual organs; the mature fern, on the other hand, produces no sexual organs, but is itself the product of bisexuality. The same criticism applies with equal force to the expression "alternation of generations," used alike by botanists and zoologists.

† As elsewhere, reference is made mainly to American literature. The more extensive European literature is already well catalogued in Goebel's Outlines, so is not repeated here.

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CHAPTER V.

FERN STRUCTURE.

Be it ours to meditate,
. . . . . .
And to the beautiful order of thy works
Learn to conform the order of our lives.
—BRYANT.

69. Tissues.—The life-history of every plant commences in a single cell, and all the complications of vegetable growth depend on two simple processes, viz., the enlargement of individual cells to their full size, and their multiplication by division. The lowest forms of vegetable life consist of a single cell, either globular or elongate. Those of a somewhat higher grade consist of a single row of cells, or at most a single layer; while still higher forms of growth consist of masses of cells variously grouped together and specialized by differentiation from the typical form and character.

70. Cells become specialized or set apart to fulfil a certain function in the economy of plant growth in many ways. Some are lengthened for giving strength to stems or leaves; some have their walls thickened to give rigidity or hardness where protection is needed from injury to more delicate structures within; and some are variously adapted for containing and distributing the secretions or other fluids connected with the circulatory system of plant life. Seven distinct varieties of tissues are recognized by structural botanists, yet some of these are connected with each other by various gradations.

71. Tissue Systems.—The earliest tendency to differentiation of cells is seen in the arrangement of the outer row of cells to form a boundary wall. In higher forms of growth the interior cells tend to form one or more series of string-like rows surrounded by the normal cellular tissue. We thus reach the basis of the classification of vegetable tissues into three groups: (a) *Epidermal System.* (b) *Fibro-vascular System.* (c) *Fundamental System* (Fig. 17). The first and third are common to both ferns and mosses. The second is first seen in the ferns and their allies, where it is a character so constant that it serves as the basis for separating the so-called "vascular" cryptogams from other flowerless plants. These three forms of tissue may be seen by examining a thin cross-section of the stipe of a living fern with the microscope. Longitudinal sections will show still further the character of the tissues composing the fibro-vascular bundle.

72. Roots.—Roots are constantly produced as the root-stock advances, and consist for the most part of little fibrils which are naked for a short distance from the apex in order that they may freely absorb moisture from the earth. The epidermis is also thin, and usually consists of a single layer of small cells. It differs from that of the rest of the plant in having no stomata (77). As the apex continues to grow, the epidermis of the part behind becomes harder, and frequently develops hairs, or more frequently irregular scales.

73. Stipe.—The stipe is made up of the three forms of tissue (Fig. 17), and usually contains several bundles of vascular tissue. In the dried stipe these can be easily seen, by scraping off the external covering of the stem. These bundles of fibres give stability to the fern, and are continued through the rachises and veins, thus forming the framework for the softer portions of the frond. The stipes are sometimes smooth and polished, sometimes hairy or beset with stalked glands, and sometimes densely clothed, especially near the base, with chaffy scales.

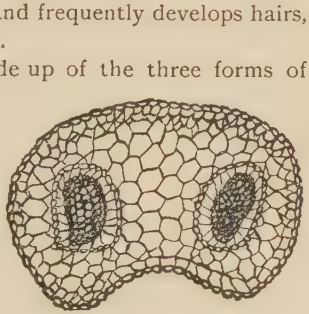

FIG. 17.—Cross-section of stipe of *Cystopteris fragilis* Bernh., showing two bundles of fibro-vascular tissue.

74. Frond.—In the HYMENOPHYLLACEÆ the frond consists of a single layer of cells. This condition is also found in the leaves developed along the axis of growth among the mosses to which this sub-order is related in some of its forms. In all other ferns there are several layers of cells variously compacted together, and forming all the varieties of texture —membranous, herbaceous, coriaceous and fleshy. The epidermis is usually easily separable from the underlying tissue, when its peculiar markings can be studied.

75. From the epidermis a great variety of appendages are developed which are all modifications of hairs, and are all included under the term *trichomes*, however different in appearance or distinct in function. These are not confined to the frond, but develop here their greatest variation. They are frequently found on the roots, the rootstock, and the stipe, under the form of root-hairs or scales of various forms. Scales are especially abundant in certain forms of *Dryopteris*, as well as in *Scolopendrium, Cheilanthes*, and other genera.

76. Trichomes.—On the fronds the trichomes may be developed as simple unarticulated or articulated hairs, consisting of one or two cells at most. They may appear as stalked glands like those that arise from the stipe of *Cheilanthes Coopere* or the margin of t e indusium of *Dryopteris spinulosa, var. intermedia*; or they may be developed into scales of intricate cellular structure like those on the under surface of certain forms of *Cheilanthes*, particularly *C. Fendleri* and *C. Clevelandii*. Among the FILICES the sporangia are specialized, trichomes developed in clusters (*sori*) along the veins, or spread over the entire surface of the frond, or even arranged in spikes or panicles. The epidermis also develops an excrescence known as the indusium, which consists of a single layer of cells, and is variously arranged as indicated in Chapter III. In some cases a false indusium is provided, which is not a growth from the epidermis, and may consist of several layers of cells.

77. Stomata.—If the epidermis covering the under surface of a fern be examined under a high magnifying power, peculiar structures will be seen in the form of semi-elliptical or crescent-shaped cells connected at their apices and separated between. These are the guard-cells of stomata which control the open-

ings to the air-chambers of the plant. The two elliptical cells form the mouth of the passage and expand when moist, allowing the atmospheric gases and watery vapor to escape or enter but close the entrance by contraction in time of drought. The stomata are not confined to the fronds, but are found to a greater or less extent on all aerial portions of ferns and higher plants, as well as on subterranean stems.

78. Asexual Reproduction.—Besides the ordinary methods of sexual reproduction discussed in Chapter IV., most ferns are propagated by growth of the rootstock under ground, giving rise to a succession of fronds each season. In addition to this, which is common to all perennial plants, there are some methods of reproduction that deserve attention. The first is by

79. Buds and Bulblets.—In a few species of conservatory ferns adventitious buds are produced on the surfaces of the fronds. These soon develop into young ferns, and it is not uncommon to see a large number in various stages of growth rising from a single frond. This peculiarity is common among several species of *Asplenium*, especially *A. furcatum* Thunb., and will be sometimes found to occur among some of our native species. Bulblets are found in the axils of the upper pinnæ of *Cystopteris bulbifera*, which often fall to the ground and develop into new plants after a manner analogous to the development of the axillary buds of the tiger-lily.

FIG. 18.—*Camptosorus rhizophyllus* Link., reduced, showing peculiar method of propagation.

80. Another method is seen in the walking-leaf (*Camptosorus rhizophyllus*), in which the long, attenuated, simple fronds bend over and take root in the adjoining soil in a manner quite analogous to the propagation of strawberries by runners (Fig. 18). The same method of rooting at the apex has also been noticed in *Asplenium pinnatifidum*, *A. platyneuron*, and *Phegopteris reptans*.

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CHAPTER VI.

THE FERN ALLIES.

Beneath my feet
The ground-pine curled its pretty wreath.
—EMERSON.

A. THE GRAPE-FERNS AND ADDER-TONGUES.

81. **General Characters.**—These peculiar plants, formerly united with the order FILICES, are now regarded as constituting a distinct botanical order. They include mostly small, fleshy, terrestrial plants, and, like ferns, may usually be found in swamps or rich, moist woods. As already noticed (5), there is a marked tendency to variation in the same species, and numerous varieties have been established from the various forms.

82. The sterile and fertile portions of the plant are borne on a common stalk, and either portion may be sessile, long

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* See other references at close of Chapter X.

or short stalked, in the various species. In *Ophioglossum* the sterile portion is simple, and in all our species except the anomalous *O. palmatum* appears like a single leaf borne on the common stalk. In *Botrychium* (Fig. 19) the sterile segment (except in some forms of *B. simplex*) is somewhat pinnately or ternately divided, and in the larger forms of *B. Virginianum* is broadly ternate, with the divisions even tri—quadripinnatifid. The veins are free in the latter genus, but anastomose in the former. This character, however, is frequently obscured by the fleshy texture of the plant.

FIG. 19.—Plant of *Botrychium lunaria*, natural size.

83. Vernation.—As has been before stated, ferns are rolled in the bud from the apex downward (*circinate*), distinguishing them from the higher forms of vegetation. Among the OPHIOGLOSSACEÆ, however, the vernation is either straight, inclined at the apex of one or both segments, or else the fertile segments are folded on the main stalk, making the vernation wholly inclined. Until recently there has been much difficulty in distinguishing the smaller species of *Botrychium*, and some forms seem to connect the smaller ones with the reduced forms of *B. ternatum* and *B. Virginianum*.

Mr. Davenport has investigated the bud characters of these intimately related species, and has made their identification a matter of comparatively easy investigation. The buds may be found enclosed in the base of the common stalk (except in *B. Virginianum*, where they are placed in an upright cavity at one

side), and may be examined with a strong lens. The three divisions are summed up as follows:

"I. Vernation wholly straight. *B. simplex* Hitch. (Fig. 31).

II. Vernation partly inclined in one or both portions. *B. lunaria* Swz. (Fig. 32), *B. boreale* Milde, *B. matricariæfolium* A. Br. (Fig. 33), and *B. ternatum* Swz. (Fig. 34).

III. Vernation wholly inclined, in the fertile frond recurved. *B. lanceolatum* Angs. (Fig. 35), and *B. Virginianum* Swz."

The special characters of each species will be found under the descriptions of the *Botrychia* later in this work. The cuts will be valuable for reference, and will enable even beginners to identify the species of this complicated genus with comparatively little difficulty.

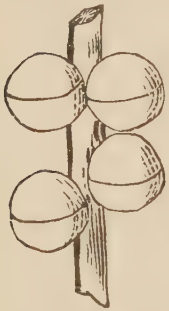

FIG. 20.—Enlarged sporangia of *Botrychium ternatum* Swz.

84. Fructification.—In this order of plants the fructification consists of sporangia, which, unlike those of the true ferns, are not reticulated, possess no trace of a ring, open by a transverse slit, and are variously spiked and panicled (Fig. 20). In the adder-tongues (*Ophioglossum*) the sporangia are large, and cohere in two ranks along the margins of a single spike, opening transversely to discharge their copious sulphur-yellow spores. In the grape-ferns (*Botrychium*) the sporangia are globular and arranged in double rows along the narrow segments, more or less in panicles. In both genera the sporangia are not developed from the epidermal cells, but arise from a transformation of the interior tissue of the leaf. This, with other characters as clearly defined, serves to separate these anomalous plants from the order FILICES.

85. Germination.—Among the OPHIOGLOSSACEÆ, so far as known, the prothallia are destitute of chlorophyll, develop under ground, and are monœcious. In *Botrychium lunaria* the prothallium is an ovoid mass of cellular tissue, light brown without and yellowish white within. It produces a number of antheridia and archegonia on the upper surface as well as the lower, differing in a few minor points from the true ferns in the method of their development.

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B. THE HORSE-TAILS.

86. General Characters.—The horse-tails or scouring-rushes belonging to the genus *Equisetum* are perennial, rush-like plants, that may be found in damp, gravelly, or loamy soil, some species even growing in shallow water. Our native species vary in height from a few inches up to eleven feet, as seen in some of the larger forms of *E. robustum*. In some species only the root is perennial, the stems which are sent up for producing fruit dying down to the ground every year. In others the stems are evergreen, continuing through the winter. Some species, like the common horse-tail (*E. arvense*), are dimorphous, the fertile stems being simple and destitute of green coloring matter (chlorophyll), while the sterile stems are green and copiously branched. The fertile stems of some other species, as *E. silvaticum*, which are simple at first, after maturing their fruit produce branches and resemble the ordinary sterile stems (Figs. 21, 22).

87. The furrowed stems are hollow, except in *E. scirpoides*, and in addition to the large central cavity there is a series of smaller air-cavities opposite the furrows known as the *vallecular canals*, the furrows themselves being called *vallecul*æ and the ridges *carin*æ. Opposite the carinæ there are still smaller cavities known as *carinal canals*. The carinæ vary in number from

FIGS. 21, 22.—*Equisetum sylvaticum* L., showing sterile and fertile stems. (From Thome.)

five to fifty in different species. The stems are also jointed, and at each node some species produce a whorl of branches which may be simple or compound. Some species, however, like the common scouring-rush (*E. hiemale*), produce simple stems.

88. The leaves are produced also at the nodes, and by the union of their margins form a short sheath which ends in a row

of teeth. These teeth may be deciduous or persistent, and their number, varying from three upwards, indicates the number of leaves forming the united whorl.

89. Stomata (77) are distributed along the valleculæ either irregularly or disposed in ranges on either side of the valleculæ. The epidermis frequently contains much silica, and the roughened tubercles of some species give the surface a harsh feeling.

90. **Fructification.**—The fructification in *Equisetum* is arranged in cone-like spikes borne at the apex of the fertile stems. These spikes are composed of successive closely-placed whorls of shield-shaped, stalked scales or modified leaves, each of which bears from five to ten one-celled sporangia on its under side. The sporangia open along the inner side to discharge their numerous spores, whose outer coat is spirally split into two bands, forming the so-called *elaters*. The elaters when dry are spread out at right angles to each other in the form of a cross, and probably assist in scattering the spores; when moist they rapidly absorb water, and become closely coiled around the spore.*

91. **Germination.**—The spores of *Equisetum* retaining their powers of germination only a few days, soon develop branched and irregularly lobed prothallia, which are provided with chlorophyll. These are usually diœcious, the male being smaller, and producing antheridia at the end or margin of the larger lobes. The antherozoids are large, and provided with a peculiar appendage known as the "float." The female prothallium may reach one half inch in length, and develops archegonia on the anterior margin of the fleshy lobes. The process of fertilization is similar to that of ferns.

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* An interesting illustration of this can be seen by placing a mass of fresh spores on a slide uncovered, and examining it with a low power. By breathing on the slide the elaters coil closely about the spore; as soon as the moisture evaporates they uncoil, and in their activity jostle each other in great confusion.

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C. THE CLUB-MOSSES.

92. General Characters.—The club-mosses are chiefly small perennial plants usually growing in dry or moist woods, or even on exposed rocks with little soil for nourishment. Most of the species are somewhat moss-like in habit, as might be suspected from the popular names given to these plants, the genus *Lycopodium* taking the name of club-moss and *Selaginella* that of rock-moss. Various species of *Lycopodium* are also known as ground-pine, ground-fir, ground-cedar, running-pine, etc., from more or less marked resemblances (Fig. 23). In the curious *Selaginella lepidophylla* from Arizona the branches of the closely coiled central stem roll up when dry into a nest-like ball, and when moistened expand so as to appear flat or saucer-

FIG. 23.—Portion of *Lycopodium clavatum* L. ½ natural size. (After Prantl.)

shaped. As the plant retains this power indefinitely, it has sometimes been called "the Resurrection-plant."

93. The stems are usually creeping, yet in some species show a tendency to become erect, and most species send up erect branches which bear the fruit. Most species bear roots at irregular intervals along the under side of the creeping stems, but our solitary species of *Psilotum* is rootless, bearing only underground shoots which perform the functions of roots. The leaves are small and unbranched, in some instances resembling appressed scales, in others resembling the acicular leaves of Conifers, and are arranged in four, eight, or many ranks. In some species the leaves are of one kind, while in others two or even more forms may occur on the same plant. In *Psilotum* the leaves are all rudimentary.

94. **Fructification.**—The fructification of the club-mosses is chiefly borne on upright branches in solitary or clustered (2–5) spikes, which are formed of numerous scales or scale-like leaves, each bearing a single large sporangium in its axil. The sporangia open transversely, and are one-celled, except in *Psilotum*, where they are three-celled. In a few species of *Lycopodium* the sporangia are borne near the summit of the fertile stems in the axils of ordinary leaves. The usual shape of the fruit-bearing scales is represented in Figs. 24–26.

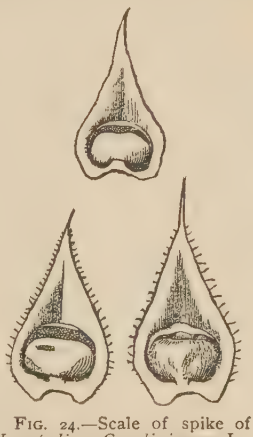

FIG. 24.—Scale of spike of *Lycopodium Carolinianum* L., bearing a sporangium in its axil.

FIGS. 25, 26.—Scales from fertile spike of *Selaginella rupestris* Spring, disclosing two sorts of spores. (After Sprague.)

95. The spores of *Lycopodium* and *Psilotum* are of one kind (Fig. 24), but in *Selaginella* two kinds of sporangia are developed—the *microsporangia*, producing numerous *microspores* (Fig. 25) not unlike the spores of *Lycopodium;* and the *macrosporangia*, producing usually four *macrospores* (Fig. 26), so called from their larger size. This character of *Selaginella*, which it shares with the quillworts and pepperworts soon to be described, serves as the basis for the division of the fern allies into two groups: the

isosporous, producing spores of one kind; and the *heterosporous*, producing spores of more than one kind.*

96. **Germination.**—The germination of *Lycopodium* is only partially known, as the prothallia have been seen in only three species, and in these they have not been carried through all the stages of development. That of *L. annotinum* is a yellowish-white mass of tissue with a few small root-hairs.† The antheridia and archegonia are developed from the upper side of the prothallium. In *L. cernuum*, Treub‡ found the prothallia much smaller (one twelfth of an inch long), vertical in growth, yellowish below and bright green above. The antheridia and archegonia are found round the summit of the cylindric prothallium.

97. The germination of *Selaginella* is better known. The contents of the ripened microspores are transformed into a mass of tissue consisting of a few cells, one of which remains sterile and is considered a rudimentary prothallium, while the others give rise to antherozoids, and are consequently considered as a rudimentary antheridium. The macrospores, on the other hand, produce a many-celled prothallium, which develop a few root-hairs and numerous archegonia, which after fertilization give rise to a new plant. Two plants are sometimes produced on the same prothallium.

98. The microspores are thus seen to be male and the macrospores female, showing a clearer differentiation of sex in the products of the mature plant than appears in any other group of the fern allies already studied. This may be considered a foreshadowing of the completely differentiated sexual organs which occur in the flowering plants. In the method of formation of the embryo the *Selaginella* also differs from all other plants of this group, and approaches the flowering plants.

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* This division, though used by some of the best botanists, is at best an artificial classification, as it separates genera otherwise closely allied to each other.

† *Cf.* J. Fankhauser, *Botanische Zeitung*, 1873, pp. 1–6; Bruchmann, *Botanisches Centralblatt*, XXI (1885).

‡ *Cf.* Treub, *Ann. d. Jard. Bot. d. Buitenzorg*, IV (1884).

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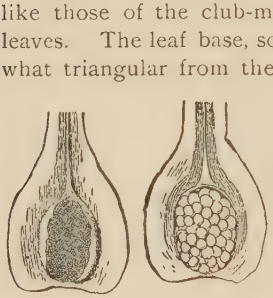
D. THE QUILLWORTS.

99. General Characters.—The quillworts, so named from the appearance of the leaves, are principally inconspicuous aquatic plants of a grass-like or rush-like aspect (Fig. 27). Some species are always submerged — often in several feet of water; others grow in marshy soil or in the shallow margins of ponds or streams, where they become apparently terrestrial in time of low water; while others still are found between high and low water marks, where they will be covered by water at high tide. The leaves are awl-shaped or linear, and are attached to a short fleshy trunk. They vary in number from ten to one hundred in each plant, and in length from two to twenty inches in various species. On account of their resemblance to the immature forms of rushes and other aquatic vegetation of a higher order, they have been very sparingly collected. Many questions of distribution, habits, and life-history may be studied by even amateur botanists in various sections of the country.

FIG. 27.—*Isoëtes lacustris* L., natural size. (Redrawn from Sprague.)

In this way valuable additions to science may be contributed by those whose labor misdirected might be wasted.

100. **Fructification.**—The sporangia of the quillworts, like those of the club-mosses, are sessile in the base of the leaves. The leaf base, sometimes called the sheath, is somewhat triangular from the broad insertion, convex behind and concave in front, where there is a large depression known as the *fovea*, which contains the sporangium. The margin of the fovea rises in the form of a delicate membrane called the *velum*, which in many species lies above the sporangium and encloses it. The sporangia of the outer leaves contain large spherical macrospores; those of the inner contain numerous oblong, triangular microspores. The size and marking of the spores form important characters in distinguishing species.



FIGS. 28, 29.—Two kinds of sporangia in *I. lacustris* L., enlarged. (After Sprague.)

101. **Germination.**—The microspore after remaining dormant through the winter forms a few-celled structure which produces the antherozoids, which are long and slender, and provided with a tuft of cilia at each end. The macrospore produces a prothallium much as in *Selaginella* (97); from this the germ of the mature plant arises after fertilization by the antherozoids.

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See also notes in *Botanical Gazette*, VI, 228.

E. THE WATER FERNS.

102. General Characters.—This group includes plants of very diverse characters. Some, like *Marsilia*, root in mud and produce quadrifoliate leaves. Others, like *Pilularia*, resemble the sterile forms of *Eleocharis*, or other sedges. Others, like *Azolla* or *Salvinia*, float on the surface of water, sending numerous roots into the water. *Marsilia* and *Pilularia* have a circinate vernation like the ferns.

103. Fructification.—The fruit of *Marsilia* consists of a hollow-stalked receptacle known as the *sporocarp*, which is oblong or rarely globose, and bears the sporangia in sori on the inner walls of its two valves. The spores are of two kinds, as in all rhizocarps. The numerous microspores are contained in microsporangia, while the macrospores are solitary in the few macrosporangia.

FIG. 30.—*Salvinia natans* Hoffm., natural size. (Redrawn from Thomé.)

104. The sporocarp of *Pilularia* is globose, containing from two to four cells, which produce microsporangia in the upper portion and macrosporangia below; the microspores are numerous, while a single macrospore is found in each sporangium.

105. In *Azolla* the sporocarps are of two kinds, borne in the axils of the leaves; the larger are globose, and contain numerous microspores, which are aggregated in masses; the smaller are ovoid, and contain a single macrospore.

106. *Salvinia* (Fig. 30), recently discovered in Missouri, has the sporocarps borne in clusters on short branches of the floating stem, one or two of each cluster bearing ten or more macrosporangia, each of which contains a single macrospore, the remainder bearing numerous globose microsporangia with numerous microspores.

107. **Germination.**—In *Marsilia* the antherozoids are produced in a rudimentary prothallium which develops from the microspore and are corkscrew-shaped, consisting of several coils. The prothallium, developed from the apex of the macrospore is a hemispherical mass of tissue, and contains a single archegonium. Much is yet to be learned of the habits and life-history of our native species.

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—— On the Prothallium and Embryo of *Marsilia vestita*. In *Proc. Cal. Acad. Science*, III, 183–205, pl. III, IV (1892).

—— Some notes on *Azolla*. In *Zoe*, III, 340–343 (1893).

—— The development of the Sporocarp of *Pilularia Americana* A. Br. In *Torrey Bulletin*, XX, 141–148, pl. CXLVI (1893).

ENGELMANN (George). New Species of *Marsilia*. In *Silliman's Journal*, Second Series, VI (1848).

STRASBURGER (L.). Ueber *Azolla*. 8vo, 7 plates. Jena (1873).

UNDERWOOD (L. M.) and COOK (O. F.). Notes on the American Species of *Marsilia*. In *Torrey Bulletin*, XIV, 89–94 (May, 1887).

CHAPTER VII.

CLASSIFICATION AND NOMENCLATURE.

The education of a naturalist now consists chiefly in learning how to compare.
—AGASSIZ.

108. Nomenclature.—Before the time of Linnæus, the method of naming plants and animals was a subject of much embarrassment to science, and gave rise to endless confusion. This great author, justly called the "Father of Botany," introduced a new system of nomenclature that gave an impetus to the study of nature. His system has since been in constant use, and has made possible the greater accuracy and definiteness in the descriptions of subsequent naturalists. He also introduced a system of classification which, though artificial and since abandoned, paved the way to the more natural system since adopted. He arranged the various plants and animals known to him in a few groups according to some particular plan of structure, divided these into still smaller groups, and so on to the lowest divisions, genera and species. To these divisions special names were assigned, thus giving to each organism a double name, the first *generic*, which may be likened to our family name, the other *specific*, corresponding to our baptismal name. Thus the "golden-back" of California bears the name *Gymnogramme triangularis* given it by Kaulfuss. The first it bears in common with other species from this and other countries which possess a like fructification. The latter is peculiar to this species, which has a somewhat triangular frond.

109. Generic Names.—These may be derived from some characteristic of growth or structure (*Cryptogramme, Cheilanthes, Schizæa*), in honor of some botanist or distinguished patron of science (*Dicksonia, Woodsia*), or occasionally from some mythological or symbolical character (*Osmunda*).

110. Specific Names.—These are usually adjective elements either Latin or Latinized, and must agree in gender with

the generic name, according to the rules of Latin syntax. Errors in agreement have frequently been made by botanists who were not versed in the classics, and it is unfortunate that errors of this character as well as gross errors in the orthography of generic names have found their way into accepted text-books of botany.* Specific names frequently indicate something regarding habit or mode of growth (*bulbifera, gracilis, atropurpurea*), or may indicate the locality in which the organism was first discovered (*Californica, Ilvensis*). A few take their name from their discover, in which case the name is Latinized and takes a genitive ending (*Boottii, Lemmoni*), or else an adjective form (*Goldieanum, Clintonianum*).

111. The advantage of this binary nomenclature is at once evident when we consider the immense number of ferns alone, to say nothing of the remainder of the vegetable world and the hosts of the animal creation. By this means organisms of complex structure can be definitely characterized with comparatively few words, and the scientific name once established, is recognized among scientists of all nations and languages.

112. Among some there is a tendency to regard scientific names with disfavor, on the ground that they are long and difficult. But what shall we say of *Geranium*, or *Gladiolus*, or *Fuchsia*, or *Phlox Drummondii*, or a hundred others familiar to every lover of flowers? Are these less difficult than *Adiantum*, *Notholæna*, *Woodsia*, or *Pellæa Breweri*? A little reflection will convince a person of sense that such a criticism is unjust.

113. A worse tendency is perhaps that which prompts the introduction of "popular names" for ferns: occasionally a name of this kind is highly appropriate, and deserves wide-spread adoption, as in the case of "Christmas-fern" for *Dryopteris acrostichoides*, suggested by Mr. Robinson; the greater part, however, have no merit, and when such monstrosities appear as "Leather-leaf Polypody" for *Polypodium Scouleri*, "Mr. Goldie's Shield-fern" for *Dryopteris Goldieana*, nomenclature is made cumbrous instead of simple.

114. There are liabilities to error and confusion even in the Linnæan system of nomenclature, as various authors have

* *Cistopteris* for *Cystopteris* is an example.

often assigned the same name to several species. For example, the name *Cheilanthes vestita* was given by Brackenridge to *C. gracillima*. Hooker assigned the same name (in part) to *C. gracilis*, while Swartz assigned the same to the fern described in this volume under the name of *C. lanosa*. It becomes necessary, therefore, in referring to a species to indicate the author of the specific name thus—*Cheilanthes vestita* Swz.

115. **Synonymy.**—It may also be remarked in this connection that different authors have described the same fern under widely different generic and specific names, owing (1) to the different conceptions that have prevailed at different times as to what constituted generic characters, and (2) to ignorance of what others had already written on species, redescribed as new. For example, the delicate *Woodsia Ilvensis* of Robert Brown was described as *Acrostichum Ilvense* by Linnæus, *Polypodium Ilvense* by Swartz, *Nephrodium rufidulum* by Michaux, *Aspidium rufidulum* by Willdenow, and *Woodsia rufidula* by Beck. Many other species have been as variously classified. The opportunities for errors of this character are much less now than formerly, yet redescription is not unknown in our day.

116. **Species.**—Goethe tells us that nature knows only individuals, and that species exist only in the school-books. From this extreme there has been every grade of opinion respecting species to the one which regards species as invariable, actual existences, types originally ordained and summoned to existence by the Creator. Linnæus, for example, defined species in these words: "*Species tot sunt diversæ, quot diversas formas ab initio creavit infinitum ens.*" * Various definitions have been given to species, but none accord with the actual practice of systematists, who seem inclined to make a species what they choose; and indeed the existence of various connecting forms between many species distinct under normal conditions makes the practical definition of the term almost an impossibility. We may, however, for practical purposes, regard as a species an assemblage of individuals not differing essentially from each other, and capable of producing like individuals by the ordinary processes of reproduction. A recent writer defines species as "the

* There are as many different species as the Infinite Being created in the beginning.

present aspect of a line of organic development, destined to become something else in the future, as it was something else in the past,"—a definition in accord with the now universally accepted biological doctrine respecting the origin of species. Species among ferns are founded chiefly on differences in the cutting of the fronds and their method of venation.

117. **Varieties.**—Many forms differing only slightly from the ordinary specific types, and yet capable of transmitting their variations from generation to generation, are regarded as varieties. It was the opinion of a prominent botanist, that all so-called varieties among the lower plants "were purely the result of the accident of environment, and never of cross-fertilization." Since a species which varies in some minor particular is likely to revert to the ordinary form as soon as the normal conditions of soil, moisture, or environment are restored, there is no scientific foundation for the multiplication of varieties to serve as rubbish in works on systematic botany. There is a tendency on the part of a few authors to multiply varieties indefinitely, and of a single species as many as sixty-five varieties have been described. The mania for naming new varieties is quite universal, but is usually transient, and seldom affects one a second time; with some, however, it becomes chronic, when more vigorous treatment is necessary. In the systematic portion of this volume varieties that are deemed worthy to stand as such are printed in the same bold-face type as the species. Others less marked are noted in italics under the descriptions of species. A true variety is doubtless the early stage of a species in process of separation from its parent form.

118. **Genera.**—The genera of ferns are founded mostly on the arrangement of the sporangia on the veins, as well as the character, shape, and position of the indusia. The generic limits, however, are largely matters of opinion, and vary among different authorities.

119. **Tribes.**—Genera are collected into tribes, according as they agree in the position and arrangement of the sporangia in clusters or sori, or resemble each other in mode or habit of growth.

120. **Sub-Orders.**—Tribes are grouped into sub-orders according as they agree in the characters of the sporangium, its

shape, method of discharging its spores, and the existence, character, or absence of a ring. The true ferns contain with us three well-marked sub-orders; the *Gleicheniaceæ* are mainly tropical ferns.

121. **Orders.**—Ferns were formerly classed in a single order, but in accordance with later researches they are separated into three distinct orders, FILICES, MARATTIACEÆ, and OPHIOGLOSSACEÆ, which are distinguished by the method in which the sporangia are developed, by the character of their spore development, and by other minor characteristics. Two of the orders are well represented in our flora; the MARATTIACEÆ are mostly confined to tropical regions. The horsetails (*Equisetum*) form a distinct order, the EQUISETACEÆ. The club-mosses of the genera *Lycopodium* and *Psilotum*, with two genera not found in America, form the order LYCOPODIACEÆ. *Selaginella* and *Isoëtes* each form an order which takes its name from the single genus. *Marsilia* and *Pilularia* form the MARSILIACEÆ, while *Azolla* and *Salvinia* form the order SALVINIACEÆ.

122. **Principle of Classification.**—The true idea of classification is the grouping together of objects according to essential and fundamental resemblances. Every system is more or less artificial, yet there is a continual approach toward the true natural system, which is the ultimatum of scientific classification. The study of life-histories will continually clear up points of relationship before unknown, and it will be long before the classification will become fixed and constant. Every new study contributes to this end.

LITERATURE.

The references to original writings would include all the botanists who have named or classified ferns since the time of Linnæus (1707–1778). Among the more prominent of these we may mention Swartz (1760–1818), Willdenow (1765–1812), Presl (1791–1849), Mettenius (1823–1866), Hooker (1785–1865), Fee (1789–1874), Milde (1824–1871), Al. Braun (1805–1875), and J. G. Baker (–). The following work gives a good review of the various systems:

SMITH (John). Historia Filicum. London, 1875. (Macmillan & Co.)

The American literature bearing on the subject is as follows:

BECK (Lewis C.). Synoptical tables of the Ferns and Mosses of the United States. In *Silliman's Journal*, IV (1829).

DAVENPORT (George E.). Aspidium spinulosum (Swz.) and its varieties. In *American Naturalist*, XII, 707–717 (1878).

—— New species of Ferns. In *Bulletin of the Torrey Bot. Club*, VI, 190. 191 (1877); VII, 50, 51 (1880); VIII, 61, 62 (1881); X, 61, 62 (1883).

—— Fern notes. In *Bulletin of the Torrey Bot. Club*, VII, 85, 86 (1880); VIII, 88, 89 (1881); IX, 20–23. 68, 69, 99–101 (1882); X, 4–7 (1883); XII, 21–24 (1885); XIII, 81, 82, 129–135 (1886); XV, 225–229 (1888).

EATON (Daniel C.). Ferns of the Mexican Boundary. In *Mexican Boundary Survey* (1857).

—— Ferns of the Southern States. In Chapman: *Flora of the Southern States* (1860).

—— Ferns of the Northern United States. In Gray: *Manual of Botany, 6th edition* (1890).

—— Notes on some of the plants in the herbaria of Linne and Michaux. In *Canadian Naturalist* (1870).

—— New and little known Ferns of the United States. In *Bulletin of the Torrey Bot. Club*, IV, 11, 12, 18, 19 (1873); VI, 33 (1875), 71, 72 (1876), 263–265 (1878), 306, 307, 360, 361 (1879); VII, 62–64 (1880); VIII, 4, 5, 99, 100 (1881); IX, 49, 50 (1882); X, 26–29, 101, 102 (1883).

—— Ferns of North America. Illustrated with colored plates by J. H. Emerton and C. E. Faxon.

—— Ferns of the Southwest. In Wheeler: *Report of the U. S. Geog. and Geol. Surveys west of the 100th meridian*, VI (1877).

—— Vascular Acrogens of California. In Watson: *Botany of California*, II (1880).

GRAY (Asa). On the discovery of two species of Trichomanes in the State of Alabama. In *Silliman's Journal*, 2d ser., XV (1853).

KUNZE (G.). Notes on some Ferns of the United States. In *Silliman's Journal*, 2d ser., VI, 80–89 (1848).

LAWSON (George). The Fern Flora of Canada. (1889.)

WILLIAMSON (John). Ferns of Kentucky. 12mo. (1878.)
—— Fern Etchings. 12mo. (1879.)

The literature relating to exotic species is very extensive Some of the more important works are the following:

BAKER (J. G.). A summary of the new Ferns which have been discovered or described since 1874. (1892.)

FEE (F. L. A.). Mémoires sur la Famille des Fougères. 4to. (1844–1873.) 289 plates.

HOOKER (W. J.). Genera Filicum. 4to. (1842.) 120 colored plates.

—— Species Filicum. 5 vols. 8vo. (1846–1864). 304 colored plates.

HOOKER (W. J.) and BAKER (J. G.). Synopsis Filicum. 2d ed., 8vo. (1874.) Contains descriptions of all the ferns of the world recognized at Kew to the date of publication.

HOOKER (W. J.) and GREVILLE (R. K.). Icones Filicum. 2 vols. folio. (1831.) 240 colored plates.

CHAPTER VIII.

THE FERN'S PLACE IN NATURE.

123. THE popular conception as to what constitutes a plant needs to be considerably enlarged and otherwise modified, for as soon as we commence to look about us after our eyes have been really opened, we find a vast array of forms varying in size and complexity of structure from the simple cells of the yeast-plant that we use in bread-making to the highly organized tree of the forest, and including such diverse forms of growth as the green scums that accumulate on ponds in summer, the gray lichens covering rocks and trees, the puff-balls and mushrooms that seemingly develop in a single night, the mosses, ferns and flowers in all their variety and beauty. Where in all this array of plants do our ferns stand, and what relations do they sustain to other plants? In answering this question we will have to give some account of the various groups of plants, pointing out their structural peculiarities and noting here and there in their appropriate place in the system such forms as are likely to be popularly recognized.

124. Aside from the plants producing flowers, the ferns and the mosses,* all of which are widely known and generally

* It should be noted that even this name is often misapplied. The lichens, which are in no way related to the true mosses, are sometimes popularly called "gray mosses." In "Evangeline" where Longfellow speaks of the trees "bearded with moss" he evidently alludes to the lichen, *Usnea barbata;* the "hanging moss" of the Pacific coast is also a lichen, *Ramalina reticulata*, which has a much more appropriate name in "lace-lichen." The "hanging moss" of the Gulf States, on the contrary, is a flowering plant whose nearest allies are in the pineapple family. Another flowering plant, *Euphorbia cyparissias*, is often called "graveyard moss" in the Northern States. This loose and confusing use of language is to be deplored, and those who know better should assist in relegating these incorrect usages to a merited oblivion.

recognized, we find two types of plants of lower grade which stand out prominently to even the unpracticed eye. Of these the first are mostly green,* and though variously known and named may be called collectively *algæ*. Like the higher plants, these low forms maintain an independent existence, drawing their nourishment directly from the air and water. Of the second group we may find examples in the mildew that spreads its white cobwebby film over the leaves of the lilac, the willow and other plants; or in the rust, red or black, that injures our fields of standing grain; or in the black smut that often replaces the ears of corn and greatly disfigures the plant. Other examples may be seen in the shelving masses that protrude from old stumps or logs, or in the bright scarlet cups that appear on the ground in rich woods in earliest spring. Whatever the color of these forms of plant growth, they may be characterized as *not green*. They represent a group of plants that require nourishment from some source besides air and water; some are parasitic—drawing nourishment from living plants or animals, while others are saprophytic –living on decaying organic matter. Though widely differing in character, we may call them all *fungi*. In addition to these forms are the lichens which are intimately related to some of the groups of fungi and cannot be considered as forming a definite group by themselves.

125. Looking over this array of forms we find that with all their diversity they may be arranged somewhat naturally in four groups as follows, commencing with the highest:

I. SPERMAPHYTES. (Seed-bearing plants.)
II. PTERIDOPHYTES. (Ferns and their allies.)
III. BRYOPHYTES. (Mosses and Liverworts.)
IV. THALLOPHYTES. (Algæ, Lichens and Fungi.)

It will be observed that the last three are all spore producers instead of seed producers like the flowering plants of the first

* Observant visitors at the seaside are familiar with the brown, purple and bright red "sea-weeds" that belong here but have their fundamental green color masked by other coloring matters. These are sometimes called "sea mosses," which is another unfortunate and confusing use of a term which ought to be confined to its particular group.

group; that the second like the first contains plants with a highly organized structure; that the third is like the first two in including plants with a distinct leafy axis, but differs in possessing a less complicated structure; while the last differs from all the others in having no distinction of stem and leaves. To bring out these and other characters more fully, and at the same time to indicate some hints of the leading subdivisions of these great groups of plants, will necessitate a more technical and tabular arrangement.

126. The **Thallophytes** include the lower forms of vegetation whose plant-body varies from a unicellular condition, through filamentous forms to a more or less highly differentiated thallus. While some forms, especially among the higher algæ, assume the habit of a leafy-stemmed plant, none attain to a true differentiation into stem and leaves. The thallophytes are most simply divided on a purely physiological basis into two main groups*:

1. *Algæ* which develop chlorophyll.
2. *Fungi* which are parasitic or saprophytic colorless plants.

127. The ALGÆ comprise the following groups:

1. CYANOPHYCEÆ. (Blue-green algæ, nostocs, etc.)
2. DIATOMACEÆ. (Diatoms, secreting a siliceous covering.)
3. CHLOROPHYCEÆ.† (Green algæ.) Consisting of four well-marked groups:
   (*a*) *Protococcoideæ*. (Green slimes, volvox, water-net.)
   (*b*) *Conjugatæ*. (Desmids, Spirogyra, etc.)
   (*c*) *Siphoneæ*. (Bladder-plants, green felts, etc.)
   (*d*) *Confervoideæ*. (Sea-lettuce, water-flannel, etc.)

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* The sexual system of classification frequently adopted in this country cannot be maintained among the fungi, and even among the algæ is at points very unsatisfactory. Moreover it groups together forms that have no near relation to each other and cannot be regarded as a natural system. It is further to be doubted if the group commonly known as Protophytes can be maintained on any rational grounds.

† The Chlorophyceæ include by far the greater part of the fresh-water algæ, though quite a number of the group are marine. The brown and red algæ of the two following groups make up the most conspicuous marine forms.

4. PHÆOPHYCEÆ. (Rock-weeds, devil's-aprons, Sargassum, and other marine forms; brown algæ.)
5. RHODOPHYCEÆ. (Red and purple algæ; mostly marine.)
6. CHARACEÆ. (Stoneworts of fresh waters.)

128. The FUNGI may be divided into four main groups:

1. MYXOMYCETES. (Slime-moulds.)*
2. SCHIZOMYCETES. (Bacteria.)
3. PHYCOMYCETES. (The lower or algal Fungi.)
4. EUMYCETES. (The higher or spore-fruit Fungi.)

129. The PHYCOMYCETES are represented by the following groups:

1. *Chytridiaceæ.* (Of simple structure, parasitic on algæ, etc.)
2. *Mucorinæ.* (Black moulds.)
3. *Entomophthorinæ.* (Fly-fungus, and others parasitic on insects.)
4. *Saprolegniaceæ.* (Water-moulds, some forms parasitic on fish.)
5. *Peronosporaceæ.* (Downy mildews, white rust, potato-rot, etc.)

130. The EUMYCETES include two types, the first known as *Basidiomycetes* bearing the spores on enlarged cells known as *basidia*, and the second known as *Ascomycetes*, from the fact that the spores are borne in sacs (known as *asci*). Of the following groups the first five are Basidiomycetes and the last six are Ascomycetes:

1. *Ustilagineæ.* (Smuts of grain, corn, etc.)
2. *Uredineæ.* (Rusts, cluster-cups, cedar-apples.)
3. *Tremellineæ.*† (Gelatinous fungi.)
4. *Hymenomycetes.* (Mushrooms, toadstools, bracket-fungi, etc.)

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* The *Myxomycetes* in their vegetative stages are unlike all other plants, consisting of naked masses of protoplasm and are capable of an apparent creeping motion. In their fruiting condition they show a superficial resemblance to some of the Gastromycetes with which they were formerly associated. Their true position in the world of life is not yet settled, some removing them entirely from the vegetable kingdom.

† This is really a composite group consisting of at least three orders. In this limited outline only the more common and conspicuous groups are noted,

5. *Gastromycetes.* (Puff-balls, earth-stars, bird's-nest fungi, stink-horns.)
6. *Saccharomycetes.* (Yeast-plant.)
7. *Gymnoascæ.* (Leaf-curl of peach, plum-pockets, etc.)
8. *Tuberaceæ.* (Truffles.)
9. *Pyrenomycetes.* (Black fungi, ergot, powdery mildews.)
10. *Lichenes.** (Lichens.)
11. *Discomycetes.* (Morels, cup-fungi, etc.)

131. Besides the above there are a large number of fungi that are mould-like or are parasitic on leaves, forming "leaf-spots." These are called *Fungi imperfecti*, because of the fact that some of them are known to be the early stages of certain ascomycetous fungi. The mould-like forms are known as *Hyphomycetes.*

132. The BRYOPHYTES include forms whose plant-body varies from a thallus to a distinct leafy axis, containing only a rudimentary fibro-vascular system, if any; their life-history involves two alternating phases: (1) A highly organized sexual phase producing antherids and archegones; and (2) A sporogonial phase living parasitically on the first and producing spores asexually. This division contains three well-marked classes:

1. *Hepaticæ.* (Liverworts.)
2. *Sphagnaceæ.* (Peat-mosses.)
3. *Musci.* (True mosses.)

133. The PTERIDOPHYTES have a well-developed fibro-vascular system of highly-developed tissues distributed through a leafy axis. Their life-history also involves two phases: (1) A thalloid phase (prothallus) producing antherids and archegones,† and (2) A highly-developed asexual phase producing spores by cell-division.

(The subdivisions of this group are more fully arranged in another portion of this work: see pp. 75–148.)

* The lichens may be placed here provisionally. Their relations to the other groups of fungi have not yet been fully determined.

† From this character the Bryophytes and Pteridophytes are sometimes called *Archegoniata*, to which group some also add the Gymnosperms.

134. The SPERMAPHYTES include the highest of the plant-world. In this group the plant-body, except in rare cases (*Lemna*, *Podostemon*, etc.) is a well-developed leafy axis containing highly differentiated tissues of every kind; the sexual reproduction consists of the union of pollen-grains (male element) with the embryo-sac (female element), resulting in the formation of an embryo which, with its coverings, constitutes the seed.* This group contains two well-marked classes†:

1. *Gymnospermæ.* (Cone-bearing trees, Cycads, etc.)
2. *Angiospermæ.* (All other seed-bearing plants.)

135. It will thus be seen that the Ferns and their allies occupy a high place in the plant-world, standing just below the seed-bearing plants. This position they maintain not only from their complexity of structure but from their evident graded relation to some of the lower forms of spermaphytes, especially to some that are now extinct.

136. To make the relations of the various groups of pteridophytes to each other and to the lower forms of plant-life more apparent than can be done in a lineal classification, we present the following outline of a possible genealogical tree:

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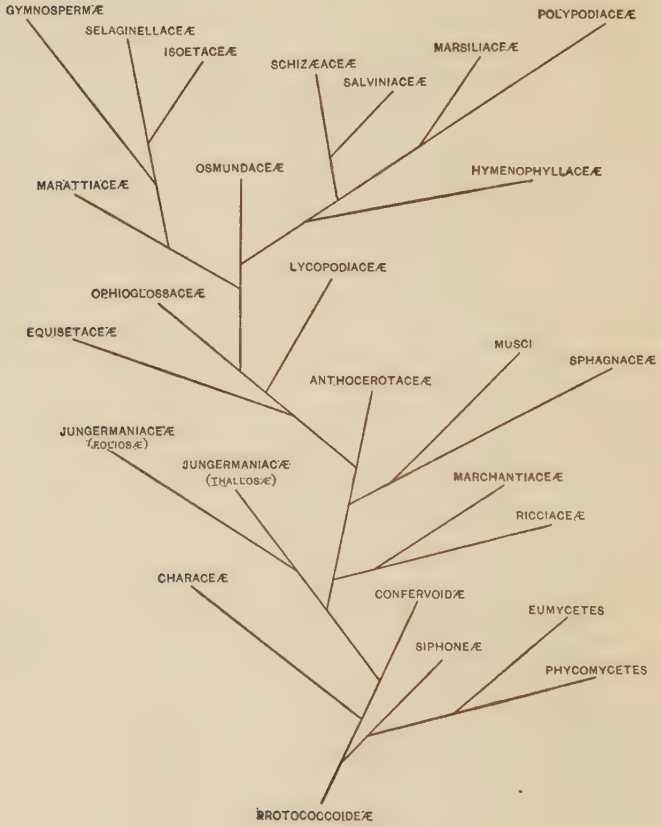
* It will be readily seen that this process is only a slight modification of what appears in the development of the higher forms of Pteridophytes like Selaginella. The prothallium, which in ferns is a marked feature, becomes reduced in Selaginella, and disappears except in rudiment in the Spermaphytes.

† The above is in accordance with the older botanical systems. The comparative and morphological study of the higher plants is leading us on to a more natural system of classification than that which is given in the ordinary Manuals of Botany. The day of artificial groups like the "Apetalous division of Exogens" is long since passed. This is not the place to discuss these changes, but this note is given merely to call attention to the progress in a field where many have been led to believe there was no further progress possible. Among the many transitional systems the following ought to be accessible in almost any good library:—*Engler-Prantl:* Natürlichen Pflanzenfamilien, II, pp. 1–5, and *Macmillan:* The Metaspermæ of the Minnesota Valley, pp. 18–29.



PROVISIONAL PEDIGREE OF THE LEADING GROUPS OF PLANTS.

LITERATURE.

BOWER (F. O.). The comparative study of the Meristem of Ferns as a phylogenetic study. In *Annals of Botany*, III, 305–322, pl. XX–XXIV (1889).

—— Is the Eusporangiate or the Leptosporangiate the more primitive type in the Ferns? In *Annals of Botany*, V, 109–134, pl. VII (1891).

CAMPBELL (Douglas H.). On the affinities of the Filicineæ. In *Botanical Gazette*, XV, 1–7 (1890).

—— A study of the apical growth of the prothallium of Ferns with reference to their relationships. In *Bulletin of the Torrey Botanical Club*, XVIII, 73–80 (1891).

—— On the relationships of the Archegoniata. In *Botanical Gazette*, XVI, 323–333 (1891).

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137. Since many students have no accessible list of the leading literature of the lower plants, and available manuals for their study for the most part have not been written, it may not be considered amiss to indicate some of the leading systematic literature relating to their study. It is not to the credit of American botany that we are obliged to this day to refer to *European* manuals as the best media for information concerning the lower plants of this country. It is to be hoped that a stimulus will be given to the study of the lower plants in all parts of the country. The literature will be arranged in conformity with the classification above given.

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FARLOW (W. G.). Marine Algæ of New England. *Report of U. S. Fish Comm.* (1879).

KIRCHNER (Oskar). Algen, in Cohn: *Kryptogamenflora von Schlesien.*

WILLE (N.). Algen, in Engler-Prantl: *Die natürlichen Pflanzenfamilien.* Contains valuable synopses of genera.

WOLLE (F.). Fresh-water Algæ of the United States. 2 vols. (1887.)

HARVEY (W. H.). Nereis Boreali-Americana. 3 parts, 4to.

(1851, 1853, 1857.) This and the next are expensive works with colored plates relating chiefly to marine forms.

HARVEY (W. H.). Phycologia Britannica. 4 vols. (1871).

DE TONI (J. B.). Sylloge Algarum omnium hucusque cognitarum. (1889.) This work covers the algæ of the world, giving compiled descriptions in Latin. Volume I (Chlorophyceæ, pp. 12, CXXXIX, 1315) only has appeared.

Diatomaceæ.

SMITH (H. L.). Conspectus of the Families and Genera of the Diatomaceæ. *The Lens*, I, 1–19, 72–93 (1872).

WOLLE (F.). The Diatomaceæ of the United States. (1891.)

VAN HEURCK (H.). Synopsis des Diatomées de Belgique. (1880.)

Desmidiaceæ.

WOLLE (F.). Desmids of the United States. (1884; 2d edition 1892.)

STOKES (A. C.). Key to the Desmidieæ. *Amer. Monthly Micros. Journal*, VII, 109–114, 125–131, 144–148, 163–169 (1886). An analytic key to the above work.

Characeæ.

ALLEN (T. F.). Characeæ of America, Part I (1888); Part II (1893).

HALSTED (B. D.). Classification and Description of the American Species of Characeæ. *Proc. Boston Soc. Nat. Hist.*, XX, 169–190 (1879).

2. FUNGI.

For the structure and biology of this group the following are useful:

DE BARY (A.). Comparative Morphology and Biology of the Fungi, Mycetozoa, and Bacteria. (English translation.) (1887.)

ZOPF (W.). Die Pilze. (1890.) Especially full on the physiology of the Fungi.

BREFELD (O.). Untersuchungen aus dem Gesammtgebiete der Mykologie. Hefte VII, VIII, IX, X (1888–1891). The most elaborate morphological work on the subject.

For the systematic study of the Fungi no single work is available for American students. The scattered literature is very abundant, and the more available portions are classified below. Among the European manuals the following is the most extensive and useful:

WINTER (G.) *et al.* Die Pilze, in Rabenhorst: *Kryptogamenflora von Deutschland, Oesterreich und der Schweiz.* Three volumes are completed and the fourth is nearly so.

Myxomycetes.

MCBRIDE (T. H.). The Myxomycetes of eastern Iowa. *Bull. Lab. Nat. Hist. State Univ.*, II, 99–162 (1892).

COOKE (M. C.). Myxomycetes of Great Britain. (1877.)

—— The Myxomycetes of the United States. *Annals N. Y. Lyceum Nat. Hist.*, XI, 378–409 (1877). An incomplete but serviceable list.

BERLESE (A. N.). Myxomyceteæ, in Saccardo: *Sylloge Fungorum*, VII, 323–450; X, 83–99.

MASSEE (Geo.). A Monograph of the Myxogastres. (1892.) To be used with caution; *cf.* criticisms in *Bulletin Torrey Bot. Club*, XX, 73–82 (1893).

Schizomycetes.

GROVE (W. B.). A Synopsis of the Bacteria and Yeast Fungi. 12mo. (1884.)

SACCARDO (P. A.). Sylloge Fungorum, VIII, 923–1087.

THAXTER (Roland). On the Myxobacteriaceæ, a new order of Schizomycetes. *Bot. Gazette*, XVII, 389-406 (1892); XVIII, 29, 30 (1893).

Phycomycetes.

FISCHER (A.). Phycomycetes, in Winter: *Die Pilze Deutschlands, Oesterreichs und der Schweiz* (1892).

FARLOW (W. G.). Enumeration of the Peronosporeæ of the United States. *Bot. Gazette*, VIII, 305–315, 327-337 (1883); Additions, IX, 37–40 (1884).

FARLOW (W. G.). The Synchitria of the United States. *Bot. Gazette*, X, 235–245 (1885).

THAXTER (Roland). The Entomophthoreæ of the United States. *Mem. Boston Soc. Nat. Hist.*, IV, 133–201, pl. 14–21 (1888).

BERLESE (A. N.) et DE TONI (J. B.). Phycomyceteæ, in Saccardo: *Sylloge Fungorum*, VII, 181–322; IX, 335–363.

Ustilagineæ.

DE TONI (J. B.). Ustilagineæ, in Saccardo: *Sylloge Fungorum*, VII, 449–527; IX, 282–291.

SETCHELL (W. A.). An Examination of the Species of the Genus Doassansia. *Annals of Botany*, VI, 1–48 (1892).

Uredineæ.

BURRILL (T. J.). Parasitic Fungi of Illinois, Part I. *Bull. Illinois State Lab. Nat. Hist.*, II, 141–255 (1885).

PLOWRIGHT (C. B.). A Monograph of the British Uredineæ and Ustilagineæ. (1889).

DE TONI (J. B.). Uredineæ, in Saccardo: *Sylloge Fungorum*, VII, 528–822; IX, 291–334.

Tremellineæ.

SACCARDO (P. A.). Sylloge Fungorum, VI, 760–815; IX, 257, 261.

Hymenomycetes.

FRIES (Elias). Hymenomycetes Europæi (1874).

SACCARDO (P. A.). Sylloge Fungorum, V; VI; IX, I 261.

PECK (Charles H.). Boleti of the United States. *Bull. N. Y. State Mus.*, II, 73–166 (1889).

MASSEE (George). A Monograph of the Thelephoreæ. *Jour. Linn. Soc.*, XXV, 107–155 (1889); XXVII, 95–205 (1890).

The following of more limited range are useful:

PECK (Charles H.). Reports of State Botanist. *Report of Regents of the State Museum of Natural History* (New York), XXII–XLIV. Contain many synopses especially of the Agaricini.

MORGAN (A. P.). The Mycologic Flora of the Miami Val-

ley. *Jour. Cincinnati Soc. Nat. Hist.*, VI, 54–81, 97–117, 173–199; VII, 5–10; VIII, 91–111, 168–174; IX, 1–8; X, 7–18, 188–202; XI, 86–95 (1883–1887).

The following more expensive illustrated works treat of the Agaricini:

FRIES (Elias). Icones Selectæ Hymenomycetum. Parts I and II. Folio. (1867–1884.) Contains two hundred colored plates.

COOKE (M. C.). Illustrations of British Fungi. 8 vols. 8vo. (1881–1887.) Illustrates over 1200 species, many of which are common to Europe and America.

Gastromycetes.

MORGAN (A. P.). North America Fungi—Gastromycetes. *Jour. Cincinnati Soc. Nat. Hist.*, XI, 141–149; XII, 8–22, 163–172; XIII, 5–21; XIV, 141–148 (1889–92).

MASSEE (George). British Gastromycetes. *Annals of Botany*, IV, 1–94 (1889).

FISCHER (E.) et DE TONI (J. B.). Gasteromyceteæ, in Saccardo: *Sylloge Fungorum*, VII, 1–180, 469–492; IX, 262–281.

PECK (Charles H.). United States species of Lycoperdon. *Trans. Albany Inst.*, IX, 285–318 (1–35) (1879).

MORGAN (A. P.). The North American Geasters. *Amer. Nat.*, XVIII, 963–970 (1884). Reprinted without the illustrations in *Jour. Mycol.*, I, 11–13 (1885).

TRELEASE (William). The Morels and Puff-balls of Madison. *Trans. Wis. Acad. Science*, VII, 105–120 (1889).

Gymnoasceæ.

ROBINSON (B. L.). Notes on the Genus Taphrina. *Annals of Botany*, I, 163–176 (1887).

SACCARDO (P. A.). Sylloge Fungorum, VIII, 811–825.

Tuberaceæ.

TULASNE (L. R. et C.). Fungi Hypogæi (1862).

SACCARDO (P. A.). Sylloge Fungorum, VIII, 863–907; X, 80–83.

Pyrenomycetes.

BURRILL (T. J.) and EARLE (F. S.). Parasitic Fungi of Illinois. Part II. *Bull. Illinois State Lab. Nat. Hist.*, II, 387–432 (1887).

BESSEY (C. E.). The Erysiphei. *7th Bien. Report Iowa Agric. Coll.* (1877).

ELLIS (J. B.) and EVERHART (B. M.). The North American Pyrenomycetes (1892).

SACCARDO (P. A.). Sylloge Fungorum, I; II; Additamenta; IX, 364–1129.

TULASNE (L. R. et C.). Selecta Fungorum Carpologia. 3 vols. 4to. (1861, 1863, 1865.)

Lichenes.

WILLEY (H.). An Introduction to the Study of the Lichens. (1887.)

TUCKERMAN (E.). Genera Lichenum. (1872.)

—— A Synopsis of the North American Lichens. Parts I and II. (1882, 1890.)

Discomycetes.

COOKE (M. C.). Mycographia, seu Icones Fungorum. Vol. I, Discomycetes. 4to. (1879.)

PHILLIPS (William). A manual of the British Discomycetes. (1887.)

REHM (H.). Discomycetes, in Winter: *Die Pilze Deutschlands, Oesterreichs und der Schweiz. III. Abtheilung.*

SACCARDO (P. A.). Sylloge Fungorum, VIII, 1–842; X, 1–79,

Fungi Imperfecti.

ELLIS (J. B.) and EVERHART (B. M.). Enumeration of the North American Cercosporeæ. *Jour. Mycol.*, I, 17–24, 33–40, 49–56, 61–67 (1885). Additions, *ibid.*, II, 1, 2; III, 13–21; IV, 2–7.

—— North American species of Ramularia. *Jour. Mycol.* I, 73–83 (1885). Additions, *ibid.*, IV, 1, 2.

—— The North American species of Glœosporium. *Jour. Mycol.*, I, 109–119 (1885). Additions, *ibid.*, III, 21.

—— North American species of Cylindrosporium. *Jour. Mycol.*, I, 126–128 (1885). Additions, *ibid.*, III, 21, 22.

MARTIN (George). The Phyllostictas of North America. *Jour. Mycol.*, II, 13–20, 25–27 (1886).

—— Enumeration and Description of the Septorias of North America. *Jour. Mycol.*, III, 37–41, 49–53, 61–69, 73–82, 85–94 (1887).

SACCARDO (P. A.). Sylloge Fungorum, III; IV; Additamenta; X, 100–739.

Hepaticæ.

UNDERWOOD (L. M.). Hepaticæ, in Gray: *Manual of Botany, 6th edition.*

—— Descriptive Catalogue of the North American Hepaticæ, north of Mexico. *Bull. Illinois State Lab. Nat. Hist.*, II, 1–133 (1884).

Sphagnaceæ.

WARNSTORF (C.). Contributions to the knowledge of the North American Sphagna. *Bot. Gazette*, XV, 127–140, 189–198, 217–227, 242–255 (1890).

BRAITHWAITE (R.). The Sphagnaceæ or Peat Mosses of Europe and North America. (1880.)

Musci.

BARNES (Charles R.). Artificial Keys to the Genera and Species of Mosses. *Trans. Wisconsin Acad. Science*, VIII, 11–81, 163–166 (1890).

LESQUEREUX (Leo) and JAMES (T. P.). Manual of the Mosses of North America. (1884.)

For any really satisfactory work in this group of plants the following more expensive publications are essential:

SULLIVANT (W. S.). Icones Muscorum and Supplement. 2 vols. (1864, 1874).

BRAITHWAITE (R.). British Moss Flora. In course of publication in parts.

BRUCH (Ph.), SCHIMPER (W. P.), et GÜMBEL (Th.). Bryologia Europæa. 6 vols. 4to. (1835–1855.) Suppl. (1864–66.)

138. The literature of the Pteridophytes has been given elsewhere in this volume, and that of the Spermaphytes is better known and need not be mentioned here.

CHAPTER IX.

DISTRIBUTION IN TIME AND SPACE.

139. Geographic Distribution.—Ferns are found in all parts of the world. The number of described species is not certainly known, and the uncertainty is largely increased for the reason that our best systematists do not agree as to what constitutes a species. Baker, whose authority is generally recognized in England and America, places the estimate at about 3000 species. Added to these are 565 fern allies as recognized by the same author.

From what has been said respecting the climatic conditions of fern growth we would naturally expect to find them most abundant in countries where warmth and moisture predominate. These conditions seem most completely met on tropical islands or in tropical continental areas with insular climates. The little island of Mauritius, having an area of 676 square miles, or less than one third the area of Delaware, has 235 native species, while Java, little larger than New York, has 460. Brazil furnishes 387, and the Isthmus of Panama 117. Comparing these with colder climates, we find 67 in all Europe, and only 26 grow within the borders of the arctic zone.

"Our Native Ferns," as described later in this volume, including those species that are classed in the order FILICES, number 158 species. Adding to these the 11 species of the order OPHIOGLOSSACEÆ, which have frequently been enumerated with the ferns, we have a total of 169 species. The remaining fern allies number 59, making a grand total of 228.

140. Divisions of our Flora.—It has been found convenient to divide the surface of the earth into faunas and floras, limited by the natural distribution of the various species of animals and plants. These limits are by no means sharply defined, for wherever the limit is made some species will pass

beyond it; yet the majority found on one side are different from the majority of those on the other. North America (excluding Mexico) forms the Nearctic realm or fauna (*Regnum Nearcticum*), and the same boundaries may be used in the limitation of our fern flora, although some species from tropical regions invade our borders in Florida, Texas, and Arizona. Leaving out of question the species that are widely distributed over the greater part of our country, many of which are cosmopolitan species, we may divide the Nearctic realm into five provinces, each of which possesses many species peculiar to itself.

141. The provinces* are as follows:

I. BOREAL: inhabiting (with a few exceptions) the northern portion of the United States, extending through Canada and British America, some species even reaching Labrador, Greenland, and Alaska, and nearly all represented also in the northern portions of the Old World.

II. MEDIAL: extending throughout the mountain and hilly region of the States east of the Mississippi, westward to the mountains, and northward into Canada, and in a few instances also inhabiting the Old World.

III. OCCIDENTAL: extending along the western border of the continent from British Columbia to California, in a few cases appearing also in the Rocky Mountain region.

IV. SONORAN: inhabiting the central mountain regions of Western Texas, Arizona, and Colorado, many of the species extending thence into Mexico, and some even to South America.

V. AUSTRAL: inhabiting the border of the Gulf of Mexico, many of the species extending into the West Indies and Tropical America.

142. The following lists will indicate the relations of our native species, though several species exceed the bounds here indicated, and occur within the borders of other provinces.

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* This division is a slight modification of one proposed by John H. Redfield in 1875. *Cf. Bulletin Torrey Botanical Club*, VI, 1–7.

BOREAL.

(Those marked * are known only from Alaska.)

Cheilanthes argentea.* Local.
Cryptogramme acrostichoides.
Pellæa gracilis.
Asplenium viride.
Dryopteris lonchitis.
aculeata, var. Braunii.
oreopteris.
fragrans.
filix-mas.
spinulosa.
Boottii.
Cystopteris montana.
Woodsia alpina.
glabella.

Botrychium lunaria. Rare and local.
boreale.* Local.
Equisetum pratense.
palustre.
litorale. Rare.
variegatum.
Lycopodium annotinum.
alpinum.
sabinæfolium.
Selaginella selaginoides.

MEDIAL.

Adiantum pedatum.
Cheilanthes lanosa.
Pellæa atropurpurea.
Woodwardia Virginica.
areolata.
Asplenium pinnatifidum.
ebenoides.
platyneuron.
angustifolium.
ruta-muraria.
montanum.
fontanum.
Bradleyi.
thelypteroides.
Scolopendrium vulgare. Rare.
Camptosorus rhizophyllus.
Phegopteris connectilis.
hexagonoptera.
dryopteris.
Dryopteris acrostichoides.
Noveboracensis.
thelypteris.
cristata.
var. Clintoniana.
Goldieana.
marginalis.
Dryopteris spinulosa, var. intermedia.
var. dilatata.
Cystopteris bulbifera.
Onoclea sensibilis.
struthiopteris.
Woodsia Ilvensis.
obtusa.
Dicksonia punctilobula.
Lygodium palmatum. Rare.
Schizæa pusilla. Local.
Osmunda regalis.
Claytoniana.
cinnamomea.

Marsilia quadrifolia. Local.
Salvinia natans. Local.
Botrychium simplex.
matricariæfolium.
lanceolatum.
Equisetum silvaticum.
limosum.
scirpoides.
Lycopodium selago.
lucidulum.
inundatum.

Lycopodium obscurum.
clavatum.
complanatum.
Selaginella apus.
Isoëtes lacustris.
Tuckermani. Local.
echinospora, var. Braunii.
var. robusta. Local.
var. Boottii.
Isoëtes echinospora, var. muricata. Local.
saccharata. Local.
riparia.
Engelmanni.
var. gracilis.
var. valida.
melanopoda.
Butleri. Rare.

OCCIDENTAL.

(Species marked * are confined to California; those marked † are found only in Oregon.)

Polypodium falcatum.
Californicum.*
Scouleri.
Gymnogramme triangularis.
Notholæna Newberryi.
cretacea.*
tenera.
Adiantum emarginatum.
Pteris aquilina, var. lanuginosa.
Cheilanthes Californica.*
viscida.*
Cooperæ.*
gracillima.
Parishii.*
fibrillosa.*
Clevelandii.*
Pellæa Breweri.
andromedæfolia.*
brachyptera.
ornithopus.*
densa.
Bridgesii.*
Lomaria spicant.
Woodwardia radicans.
Phegopteris alpestris.
Dryopteris munita.
mohrioides.*
aculeata.*
var. Californica.*
var. angularis.*
Nevadensis.*
rigida, var. arguta.
Woodsia scopulina.
Oregana.
Azolla filiculoides.
Marsilia vestita.
Pilularia Americana.
Equisetum telmateia.
robustum.
Selaginella Oregana.
Douglasii.
Isoëtes pygmæa.*
Bolanderi.
Howellii.†
nuda.†
Nuttallii.
Suksdorfii.
maritima.

SONORAN.

(Species marked * are found in our region only in Arizona; those marked † are Texan.)

Polypodium thysanolepis.*
Gymnogramme Ehrenbergiana.
Notholæna sinuata.
ferruginea.
Parryi.
Notholæna Aschenborniana.*
candida.
Hookeri.
Schaffneri.†

Notholæna Grayi.
Lemmoni.*
nivea.
Fendleri.
Adiantum tricholepis.†
Cheilanthes Pringlei.*
Wrightii.
leucopoda.†
lendigera.*
gracilis.
tomentosa.
Fendleri.
myriophylla.
Lindheimeri.
Pellæa aspera.
pulchella.
Pellæa ternifolia.†
Wrightiana.
flexuosa.
intermedia.
Asplenium monanthemum.*
septentrionale.
Glenniei.*
Dryopteris juglandifolia.
Mexicana.
Woodsia Mexicana.
Aneimia Mexicana.†

Marsilia macropoda.
uncinata.
vestita, var. tenuifolia.†
Selaginella lepidophylla.
Pringlei.

AUSTRAL.

(Species marked * are found in our region only in Florida.)

Acrostichum aureum.*
Polypodium plumula.*
pectinatum.*
polypodioides.
aureum.*
phyllitidis.*
Swartzii.*
Tænitis lanceolata.*
Vittaria lineata.*
Adiantum capillus-veneris.
tenerum.*
Pteris longifolia.*
serrulata.
aquilina, var. caudata.
Cheilanthes microphylla.
Alabamensis.
Ceratopteris thalictroides.*
Blechnum serrulatum.*
Asplenium serratum.*
parvulum.
dentatum.
firmum.
cicutarium.*
rhizophyllum, var. myriophyllum*
var. Biscaynianum*
Phegopteris tetragona.* Rare.
Phegopteris reptans.* Rare.
Dryopteris trifoliata. Rare.
contermina, var. strigosa.*
patens.
unita, var. glabra.*
Floridana.*
Nephrolepis exaltata.*
acuta.* Rare.
Trichomanes Petersii. Local.
radicans.
Aneimia adiantifolia.*

Ophioglossum crotalophoroides.
nudicaule.
palmatum.*
Equisetum lævigatum.
Lycopodium inundatum, var. pinnatum.*
alopecuroides.
cernuum. Rare.
Carolinianum.
Psilotum nudum. Rare.
Selaginella Ludoviciana. Rare.
rupestris, var. tortipila. Rare.
Isoëtes melanospora. Local.
flaccida.*
var. Chapmani.*

COSMOPOLITAN SPECIES.

Polypodium vulgare.
Pteris aquilina.
Asplenium trichomanes.
filix-fœmina.
Cystopteris fragilis.

Azolla Caroliniana.

Ophioglossum vulgatum.
Botrychium Virginianum.
ternatum.
Equisetum arvense.
hiemale.
Selaginella rupestris.

143. Local Lists.—The number of species found in a single locality is usually limited, yet in certain favored locations there is a marked diversity. As an instance, in one of the *habitats* of the rare hart's-tongue * the writer has collected twenty-seven species illustrating fourteen genera within the radius of a thousand feet. Such localities, however, are comparatively rare, and must include wide diversity of soil and shade within very narrow limits.

Onondaga County, New York, possesses perhaps as many ferns as any county in the entire country, including 41 species. 32 are catalogued from Essex County, Massachusetts. Several State lists more or less complete have been compiled, and are noticed in the literature below. Carefully prepared lists from all the States and Territories would be a valuable addition to our knowledge of geographic distribution.

144. Geologic Distribution.—It is well known that the plants and animals now existing on the earth are not the same in kind as those of former ages. Geologists have carefully studied the stony heart of nature, and have drawn therefrom the story of the development of land and sea, and the successive populations that from time to time have held possession of our globe. Plants furnishing the natural food for animals must have preceded animal life, yet in the earliest geologic ages the remains of animals are far more numerous. The abundance of the deposits of graphite and iron-ore in the earliest or Archæan rocks indicates the existence of extensive plant growth, but the remains are so transformed as to make it impossible to determine the character of this primeval vegetation.

145. In the succeeding Silurian age the fossil remains indicate the existence of algæ or sea-weeds in abundance, and a

* "Green Pond," one mile east of Jamesville, Onondaga County, New York.

single small species of ground pine attests the existence of some of the higher *Cryptogamia;* no ferns, however, have been found in America older than the Devonian. Over fifty species of Devonian ferns have been described from the American rocks chiefly, by Principal J. W. Dawson of Montreal.

146. It is in the coal measures, however, that ferns and other *Cryptogamia* are found in the greatest abundance and profusion. Their delicate foliage is impressed on the various rock strata above the beds of coal, and so perfectly are they preserved that not only the methods of fructification but even the microscopic spores have been detected! In the coal measures of the United States and Canada (counting from the base of the Catskill), 381 species of ferns have been described, chiefly by Prof. Leo Lesquereux. The most abundant American genera are *Neuropteris* 45 species, *Pecopteris* 50 species, *Sphenopteris* 31 species, *Pseudopecopteris* 25 species, and *Rhacophyllum* 24 species.

The frontispiece gives an ideal representation of the vegetation of the Carboniferous age. The luxuriant tree-ferns, the *Lepidodendrids*, ancient representatives of the diminutive club-mosses or ground-pines, the *Calamites*, allies of the modern scouring-rushes, and other forms no less wonderful, are seen in their profusion.

147. In the later geologic ages, Mesozoic and Tertiary, ferns are found preserved in the rocks, with the leaves of many trees and shrubs of existing genera. The indications are that ferns formed a far smaller part of the vegetation of these later ages than in the preceding Carboniferous, and even approximated to that of the present. Six Cretaceous and twenty-four Tertiary species have been catalogued,* including species in the existing genera *Lygodium, Pteris, Woodwardia, Dryopteris, Gymnogramme,* etc., as well as some related to genera abundant in earlier formations. No living species is found fossil, unless Dr. Newberry's variety of *Onoclea sensibilis* becomes established.† In the course of geologic history, however, we can

* Tenth report, Hayden Geological Survey of the Territories. Washington, 1878.

† Prof. Lesquereux writes me: "Though analogous by the nervation, I doubt the identity on account of the coriaceous character of that fossil fern,

trace a gradual approximation to the modern types from the generalized forms of Devonian and Carboniferous times.

148. **Fern Allies.**—*Ophioglossum* dates back to the Tertiary period with one species. The order EQUISETACEÆ have existed since the coal period and the genus *Equisetum* since the Triassic. The order CALAMARIACEÆ, which combined characters of modern *Equiseta* and Conifers, came into existence in the Devonian, but became extinct before the close of the Permian. Illustrations of *Calamites* can be seen at the left-hand corner of the frontispiece, also under the tree-fern in the centre. The club-mosses proper have been in existence since the Devonian, and the genus *Lycopodium* since the Carboniferous. *Selaginella* has never been found fossil, but its near relatives belonging to the extinct orders LEPIDODENDRACEÆ and SIGILLARIACEÆ were very abundant in the Palæozoic era, particularly during the Carboniferous, where they formed the largest part of the forest vegetation, reaching in some instances a height of seventy to one hundred feet. The former possessed characters connecting modern club-mosses with Conifers, while the latter seem to connect the club-mosses with the Cycads. Restorations of *Lepidodendron* may be seen on the left-hand side of the frontispiece, and of *Sigillaria* on the right. *Isoëtes* dates back to the Miocene (Tertiary) and *Marsilia* and *Pilularia* to the same period.

LITERATURE.

Besides the works referred to below, many State floras will give additional information respecting local distribution. Among the more important of these are those of New Jersey (*Britton*), Ohio (*Beardslee*), North Carolina (*Curtiss*), Wisconsin (*Lapham*), Vermont (*Perkins*), New Hampshire (*Flint*), Pacific Coast (*Lemmon*), Illinois (*Patterson*), New York (*Torrey*), Michigan (*Wheeler and Smith*), Indiana (*Coulter and Barnes*), Iowa (*Arthur*), Minnesota (*Upham*), Missouri (*Tracy*).

BURGESS (T. W. J.). Recent Additions to Canadian Filicineæ. In *Transactions Royal Society of Canada* (1886).

which I have not seen in any variety of *O. sensibilis* now living." Principal Dawson, however, writes: "The *Onoclea sensibilis* of the Laramie is truly that species, and I have found with it in our Manitoba formations another modern fern, *Davallia tenuifolia*."

DAVENPORT (George E.). Catalogue of the "Davenport Herbarium" of North American Ferns. Salem (1879). Supplement (1883).

—— Some Comparative Tables showing the Distribution of Ferns in the United States of North America. In *Proceedings American Philosophical Society*, 1883, 605–612.

MACOUN (John) and BURGESS (T. W. J.). Canadian Filicineæ. In *Transactions Royal Society of Canada* (1884).

REDFIELD (John H.). Geographical Distribution of the Ferns of North America. In *Torrey Bulletin*, VI, 1–7 (1875).

Minor notes on distribution will also be found in the following journals:

Botanical Gazette, I, 11, 22, 27; II, 55, 62; III, 82; IV, 128, 139, 177, 232; V, 15, 39; VI, 195, 220, 248; VII, 76, 96, 160; X, 370; XII, 63, 67, 181; XII, 117.

Torrey Bulletin, II, 24, 28; III, 2, 33; IV, 2, 17, 42; V, 38, 39; VI, 8, 175, 177, 199, 206, 221, 234, 291, 345, 347; VII, 16, 80, 89, 94, 96, 118; VIII, 47, 93, 105, 127, 144; IX, 55, 71, 128; X, 32, 40; XI, 7, 67; XIV, 97, 149.

Other notes still will be found in Mr. Davenport's series of "Fern Notes" and Prof. Eaton's series of "New and Rare Ferns of the United States," together with much of the remaining descriptive literature noted in Chapter VIII. on the Ferns and their allies. The literature on fossil ferns is very extensive. A valuable work on the coal flora will be found in the Reports P and PP of the Second Geological Survey of Pennsylvania.

CHAPTER X.

METHODS OF STUDY.

The great benefit which a scientific education bestows, whether as training or as knowledge, is dependent upon the extent to which the student . . . learns the habit of appealing directly to Nature.—HUXLEY.

149. Determination of Species.—The first thing to learn about a plant or animal is not its name, but its structural characteristics, knowing which the name can be readily deter-

mined. Having provided ourselves with a strong lens, two or more needles mounted in wooden handles for dissecting purposes, and a few well-fruited ferns taken with the roots, we are prepared to commence our study. In investigating any plant we should be systematic and accurate in our observations, and no subject will develop order and accuracy of description or enlarge our powers of observation as will the subject of botany rigidly pursued. In order to fix the characters of the fern in question, it is well to note them down in some systematic order, and the preparation of blanks like the following is suggested for the purpose:

Synoptical characters of _____	
ROOT.	
ROOTSTOCK.	
STIPE.	
FROND.	
VEINS.	
SORI.	
SPORANGIA.	
SPORES.	

The characters thus commence with the lowest parts and continually advance upwards to completion.

150. Taking now a common fern, we will notice its characteristics. Suppose it to be the one commonly called "Maidenhair" in the Northern States. We take the parts in order and give them a searching examination: the character of the root; the direction of growth, position and appearance of the rootstock; the appearance, color, and method of growth of the

stipe; the method of cutting of the frond and the character of its surface; the method of veining; the position of the fruit clusters on the frond and veins, and the peculiar form of the indusium, if present. The sporangia and spores are best studied with a microscope, yet the shape of the sporangia and the character of the ring can be determined with a strong lens.

151. The characters of the Maidenhair can be summed up as follows:

Synoptical characters of ADIANTUM PEDATUM L.	
ROOT.	Many delicate fibres, somewhat matted.
ROOTSTOCK.	Scaly, somewhat creeping.
STIPE.	Separate, slender, polished, black, forked at base of frond, forming two recurved rachises.
FROND.	Roundish in outline, formed of several pinnæ, which branch from the recurved rachises; pinnules unequal sided. oblong or deltoid; upper margins irregularly lobed; surfaces smooth.
VEINS.	Free, several times forked.
SORI.	Borne at the end of the veins on the under side of the reflexed margins of the lobes, which form somewhat kidney-shaped membranous indusia.
SPORANGIA.	Globose, with a nearly complete vertical ring.
SPORES.	Minute, of one kind.

152. We are now prepared to determine the specific name, and for this purpose will turn to the "ARTIFICIAL SYNOPSIS OF ORDERS" (p. 75), where we read the statements under A, with the first of which our plant agrees; then to B as directed, where we find it agrees with the third statement; then to C, where we determine the Order to which our plant belongs. After having determined the plant to be a member of the order FILICES, we proceed to the "ARTIFICIAL SYNOPSIS OF GENERA" (p. 80). Reading the two statements under A we find our plant agrees with the first, bearing the sporangia at the margin of a leafy frond, so we proceed to B as indicated at the right-hand mar-

gin. There being an indusium present, we are directed to C, where we find four statements. Our fern agrees with the second, as the indusium is formed of a reflexed portion of the frond. Passing to D we find it agreeing with the first statement. Passing to E, the statement, "Sporangia at the ends of the veins, borne on a reflexed portion of the margin of the frond," answers our purpose, and the marginal reference indicates the genus *Adiantum*. Under this genus (p. 89) we find two statements designated by $_{*}$, and $_{**}$; the latter referring to the "dichotomously forked" fronds, answers our purpose, and we find our fern to be number 5, *Adiantum pedatum* L., the scientific name of the Maidenhair, which we can now place in our description. Were we in Florida or any of the Southern States, instead of *A. pedatum* we would probably have found the Venus' Hair (*A. capillus-veneris*), or in California the Californian Maidenhair (*A. emarginatum*), either of which would agree with the common Eastern species in all respects save the method of branching of the frond and the shape of the pinnules. In like manner we can trace any of our native species to their scientific names, by carefully noting their structure and methods of fruiting.

153. In a few ferns it will be necessary to exercise great care in the examination of the indusia. In the genera *Cystopteris*, *Dicksonia*, and *Woodsia*, and in a few species of *Dryopteris*, the indusia wither away after fruiting, so that one is likely to classify them under the non-indusiate genera if he carelessly examines them in this condition. In such cases a large number of sori should be carefully examined, and the least trace of an indusium should be noted. Five sixths of our genera, including four-fifths of our species, are indusiate.

154. **Fern Allies.**—In determining the species of the fern allies the method of procedure is quite similar to that indicated above for the Maidenhair, in each case referring the plant to its proper order. The specimens must be in fruit, and in the case of *Equisetum* must include both sterile and fertile shoots. As the species of *Isoëtes* differ mainly in the size, character, and markings of the spores, they will require a microscope with micrometers for successful determination, though some can be identified with a lens if the life habits are also known.

155. Histology.—We have now gained a slight knowledge of the more apparent characters of the fern as viewed from without, and have been formally introduced to the species in hand by name. With some the study might seem to be at an end, but in fact it has only fairly begun. The minute structure, the development and the life-history of our fern, is yet unknown, leaving the most important features yet to be ascertained. Classification as it now exists is only a temporary arrangement, for the true relations of our species can never be fully determined until their minute anatomy and life-histories have been thoroughly studied and compared. The minute anatomy has been carefully studied in only a few of our native ferns, and fewer still have been watched through the phases of their life-history. Less still is known of the species of fern allies. There is no fear of exhausting the subject, and even amateur botanists with the most limited facilities can do something in original investigation.

156. Guides to Study.—It is impossible within the limits of a manual of this character to do more than suggest guides for study, yet no guide can be followed blindly to the exclusion of native common-sense. For the study of anatomy the works already mentioned under Chapter V. will serve for reference, while the following laboratory guides, each containing an outline for the study of a single fern, will be found valuable:

ARTHUR (J. C.), BARNES (C. R.) and COULTER (J. M.). Handbook of Plant Dissection. New York (1886). (Henry Holt & Co.). For *Adiantum pedatum*.

BOWER (F. O.) and VINES (S. H.). A Course of Practical Instruction in Botany, Part I. London (1885). (Macmillan & Co.) For *Aspidium filix-mas* and fern allies.

SEDGWICK (W. T.) and WILSON (E. B.). General Biology. Part I. New York (1886). (Henry Holt & Co.). For *Pteris aquilina*.

157. For the study of life-histories the recent paper by Dr. Campbell on *Onoclea struthiopteris* can well serve as a model. (*Cf.* Literature under Chapter VI.) The study of fern structure and fern development will grow in interest at every step, and will result in contributions of value to the knowledge of our native ferns and their allies.

OUR NATIVE PTERIDOPHYTES.

PTERIDOPHYTA Cohn.

Vascular acrogens containing woody tissue in the stems. Antheridia or archegonia or both formed on a prothallus which is developed from the spore on germination, and upon which the asexual plant is produced. Includes eight living and three extinct orders, all represented in North America.

ARTIFICIAL SYNOPSIS OF ORDERS.

A { Isosporous, *i.e.*, spores of one kind, ... B
{ Heterosporous, *i.e.*, spores of two kinds, ... D

B { Plant rush-like, . . . *Order* V. EQUISETACEÆ, p. 132
{ Plant moss-like, . . *Order* VI. LYCOPODIACEÆ, p. 135
{ Plant fern-like, ... C

C { Vernation erect or inclined ; sporangia not reticulate, in spikes or panicles, opening by a transverse slit. *Order* IV. OPHIOGLOSSACEÆ, p. 128
{ Vernation circinate ; sporangia reticulate, provided with a ring, usually borne on the back or margin of a frond sometimes in spikes or panicles, *Order* I. FILICES, p. 75

D { Terrestrial, moss-like plants, *Order* VII. SELAGINELLACEÆ, p. 140
{ Aquatic, rooting in mud, ... E
{ Aquatic, floating, . . . *Order* III. SALVINIACEÆ, p. 127

E { Leaves awl-shaped, tubular, containing the sporangia in their axils, . . . *Order* VIII. ISOETACEÆ, p. 142
{ Leaves quadrifoliate or filiform ; sporangia enclosed in sporocarps borne on separate peduncles, . . . *Order* II. MARSILIACEÆ, p. 125

ORDER I. FILICES Juss.

Plant body consisting of fronds usually raised on stipes rising from a prostrate, ascending, or erect rootstock, circinate in vernation. Sporangia modified trichomes of the leaves, reticu-

late, one-celled, encircled by a more or less complete, jointed elastic ring, collected in clusters of various forms on the under surface of the frond, with or without an indusium or covering; or panicled, or spiked and naked; or borne on receptacles of various kinds. Spores of various forms, minute. Prothallium above ground, green, monœcious or diœcious. Contains six well-marked sub-orders, four of which are represented with us. Genera, seventy,* of which we have representatives of thirty.

SUB-ORDER I.—POLYPODIACEÆ Presl.

Sporangia pedicelled, surrounded more or less completely by a jointed, vertical, and elastic ring, bursting transversely. Sori dorsal or marginal, borne on a leafy frond, with or without indusia.

TRIBE I. ACROSTICHEÆ. Sporangia spread in a stratum over the under surface, or rarely over both surfaces of the frond. Indusia wanting.

I. **Acrostichum** L. Sori covering the entire surface of the upper pinnæ.

TRIBE II. POLYPODIEÆ. Sori dorsal, borne at or near the ends of the veinlets, without indusia.

II. **Polypodium** L. Possessing characters of the tribe.

TRIBE III. GRAMMITIDEÆ. Sori dorsal, variously arising from the veins, usually linear. Indusia wanting.

III. **Gymnogramme** Desv. Sori oblong or linear, following the course of the veinlets.

IV. **Notholæna** R. Br. Sori on the veins or near their extremities, roundish or oblong, soon confluent into a narrow marginal band.

V. **Tænitis** Swz. Sori linear, central, or submarginal.

TRIBE IV. VITTARIEÆ. Sporangia borne in a continuous marginal or intra-marginal furrow.

VI. **Vittaria** Sm. Fronds simple, linear, grass-like.

TRIBE V. PTERIDEÆ. Sori marginal or intra-marginal, provided with an indusium formed of the reflexed margin of the frond, and opening inwardly.

* This number is based on Hooker's classification. Other authors, narrowing the limits of generic characters, recognize a greater number. Smith, for example, publishes 220 and Presl 230, yet the tendency among most botanists is to restrict the number.

* *Sporangia borne on a reflexed portion of the margin of the frond.*

VII. **Adiantum** L. Sori usually numerous and distinct. Midrib of the pinnules near the lower margin or wanting.

** *Sporangia borne on a continuous vein-like receptacle which connects the apices of the veins.*

VIII. **Pteris** L. Sori continuous. Indusium delicate, whitish. Midribs of pinnules central.

*** *Sporangia at or near the ends of unconnected veins, borne on the under surface of the frond.*

IX. **Cheilanthes** Swz. Sori minute, at the ends of the veins. Indusium continuous or interrupted.

X. **Cryptogramme** R. Br. Sporangia on the back or near the ends of the veins forming oblong or roundish sori, which are at length confluent and cover the back of the pinnules. Sterile and fertile fronds unlike, smooth.

XI. **Pellæa** Link. Sori on the upper part of the veins, distinct, or mostly forming a marginal band of sporangia. Sterile and fertile fronds usually similar, smooth.

TRIBE VI. CERATOPTERIDEÆ. Sori on two or three longitudinal veins which are nearly parallel with the edge of the frond. Habits aquatic.

XII. **Ceratopteris** Brong. The only genus; having the characters of the tribe.

TRIBE VII. BLECHNEÆ. Sori dorsal, linear or oblong, borne on transverse veins, parallel to the midrib. Indusium fixed at its outer margin, opening at the inner.

* *Veins free.*

XIII. **Lomaria** Willd. Sori in a continuous band next the midrib. Indusium elongate, formed of the recurved and altered margin of the pinnæ, or else sub-marginal. Fronds of two sorts, elongate, pinnate.

XIV. **Blechnum** L. Sori linear, elongate, continuous near the midrib. Indusium continuous. Fronds pinnate.

** *Veins more or less reticulate.*

XV. **Woodwardia** Sm. Sori linear or oblong, forming chain-like rows. Indusia separate.

TRIBE VIII. ASPLENIEÆ. Sori dorsal, linear or oblong,

oblique to the midrib, or rarely sub-parallel with it. Indusium fixed by one margin to the veinlet, opening at the other, sometimes double.

** Veins free.*

XVI. **Asplenium** L. Sori on the upper side of a fertile veinlet, rarely on both sides.

XVII. **Scolopendrium** Sm. Sori linear, confluent in pairs, which appear like a single sorus with the double indusium opening in the middle.

*** Veins reticulate.*

XVIII. **Camptosorus** Link. Sori oblong or linear, borne partly on veins parallel to the midrib, partly on veins oblique to the midrib.

TRIBE IX. ASPIDIEÆ. Sori dorsal, round or roundish, on the back or rarely on the apex of a vein. Indusium usually membranous, rarely wanting.

** Without indusia.*

XIX. **Phegopteris** Fee. Sori round, rather small, borne on the back of the free veins.

*** With indusia.*

† Indusia superior.

XX. **Dryopteris** Adans. Indusium orbicular and fixed by the centre, or reniform and fixed by the sinus, opening all round the margin. Sori mostly on the back of the veins.

XXI. **Nephrolepis** Schott. Indusium reniform, fixed at the sinus or at the arcuate base, opening toward the margin of the frond. Sori at the end of free veins.

†† Indusia fixed by a broad base partly under the sorus.

XXII. **Cystopteris** Bernh. Indusium convex, usually reflexed as the sporangia ripen. Texture delicate.

††† Indusia obscure. Fertile frond much contracted, very unlike the sterile.

XXIII. **Onoclea** L. Sori dorsal on the veins of the contracted pinnæ, concealed by their revolute margins.

†††† Indusia inferior.

XXIV. **Woodsia** R. Br. Indusium roundish or stellate, delicate, cleft into irregular lobes.

TRIBE X. DICKSONIEÆ. Sori roundish or transversely elongate, borne at the ends of the veins or on marginal cross-veinlets, with an indusium attached at the base or base and sides and opening toward the margin of the segment.

XXV. **Dicksonia** L'Her. Sori marginal, small, the indusium cup-shaped, somewhat two-valved, the under portion confluent with a lobule of the frond.

SUB-ORDER II.—HYMENOPHYLLACEÆ Endl.

Sporangia borne on an elongate, often filiform, receptacle, surrounded by a complete transverse ring, opening vertically. Sori terminal or marginal from the apex of a vein. Indusium inferior, usually of the same texture as the frond. Fronds delicately membranous and pellucid.

XXVI. **Trichomanes** Sm. Indusia tubular, cup-shaped, or funnel-shaped, sometimes two-lipped.

SUB-ORDER III.—SCHIZÆACEÆ Presl.

Sporangia ovate, sessile, arranged in spikes or panicles, having a complete, transverse, articulated ring at the apex, and opening by a longitudinal slit.

* *Stems scandent.*

XXVII. **Lygodium** Swz. Sporangia borne in a double row on narrow fertile segments, each on a separate veinlet and provided with a special indusium.

** *Stems not scandent.*

XXVIII. **Aneimia** Swz. Sporangia naked, attached by their bases to the narrow divisions of the panicled fertile segments of the frond.

XXIX. **Schizæa** Sm. Sporangia naked, fixed in a double row to the midrib of the narrow fertile segments. Sterile fronds simple or dichotomously forked.

SUB-ORDER IV.—OSMUNDACEÆ R. Br.

Sporangia naked, globose, mostly pedicelled, with no ring or

mere traces of one around the apex, opening into two halves by a longitudinal slit.

XXX. **Osmunda** L. Fertile pinnæ or fronds much contracted, bearing the large and abundant sporangia on the margins of the narrow segments.

ARTIFICIAL SYNOPSIS OF GENERA.

A
- Sporangia collected in sori and borne on the back or margin of a leafy frond . . . . . **B**
- Sporangia in spikes or panicles not on the leafy portion of the frond . . . . . **U**

B
- Sori covered with indusia . . . . . **C**
- Sori naked . . . . . **P**

C
- Fertile frond closely rolled together, entirely unlike the sterile, its segments berry-like or necklace-like . . XXIII. ONOCLEA, p. 119
- Sori marginal, covered with a reflexed portion of the frond . **D**
- Sori marginal or terminal, borne on an elongate receptacle, XXVI. TRICHOMANES, p. 122
- Sori dorsal or marginal, provided with special indusia . . . **H**

D
- Terrestrial, growing mostly in rocky places . . . . . **E**
- Aquatic, sterile fronds floating on the water, XII. CERATOPTERIS, p. 101

E
- Sporangia at the ends of the veins, borne on a reflexed portion of the margin of the frond . . . . . VII. ADIANTUM, p. 89
- Sporangia borne on a continuous, marginal, vein-like receptacle connecting the apices of the veins . . . . . VIII. PTERIS, p. 90
- Sporangia at or near the ends of unconnected veins, borne on the under surface of the frond . . . . . **F**

F
- Fronds conspicuously dimorphous; stipes light-colored, X. CRYPTOGRAMME, p. 97
- Fronds nearly uniform; stipes usually dark . . . . . **G**

G
- Sori on the upper part of the veins, mostly forming a continuous marginal band; indusium membranous, continuous round the segment, XI. PELLÆA, p. 97
- Sori minute, at the ends of the veins; indusium interrupted, or if continuous, the ultimate segments usually small and bead-like; fronds mostly chaffy, woolly, or farinose, . . IX. CHEILANTHES, p. 91

H
- Sori roundish; indusia not more than twice as long as broad . **I**
- Sori linear or oblong; indusia more than twice as long as broad **L**

I
- Indusium superior, attached by the centre or sinus . . . . . **J**
- Indusium convex, fixed by a broad base partly under the sorus, XXII. CYSTOPTERIS, p. 118
- Indusium inferior . . . . . **K**

J
- Sori mostly on the back of the veins; indusium orbicular or reniform, opening all round the margin . . . XX. DRYOPTERIS, p. 110
- Sori at the end of a free vein; indusium reniform, opening toward the margin of the frond; fronds simply pinnate, the pinnæ articulated to the rachis . . . . . XXI. NEPHROLEPIS, p. 117

K
- Indusium roundish or stellate, delicate . . XXIV. WOODSIA, p. 119
- Indusium cup-shaped, somewhat two-valved, XXV. DICKSONIA, p. 121

L
- Sori all parallel to the midribs or rachises . . . . . **M**
- Sori all oblique to the midribs . . . . . **O**
- Sori partly oblique and partly parallel to the midrib; frond simple, tapering to a point . . . . . XVIII. CAMPTOSORUS, p. 108

M
- Veins free . . . . . **N**
- Veins reticulate . . . . . XV. WOODWARDIA, p. 102

N
- Indusium near the margin; fertile frond much contracted, XIII. LOMARIA, p. 101
- Indusium remote from the margin; fronds nearly uniform, XIV. BLECHNUM, p. 102

O
- Sori on the upper side of a veinlet, rarely on both sides, XVI. ASPLENIUM, p. 103
- Sori confluent in pairs, with an apparently double indusium opening in the middle . . . . . XVII. SCOLOPENDRIUM, p. 107

P
- Sori spread in a stratum on the under surface of the frond, I. ACROSTICHUM, p. 82
- Sori roundish, or not more than twice as long as broad . . . **Q**
- Sori usually linear, always more than twice as long as broad . **R**

Q
- Stipes articulated to the rootstock; fronds (in our species) entire or simply pinnate . . . . . II. POLYPODIUM, p. 82
- Stipes not articulated to the rootstock; fronds (in our species) bi—tripinnatifid or ternate . . . . . XIX. PHEGOPTERIS, p. 108

R
- Fronds simple . . . . . **S**
- Fronds pinnate to quadripinnate . . . . . **T**

S
- Fronds very narrow, grass-like; veins indistinct, free, VI. VITTARIA, p. 89
- Fronds broader; veins anastomosing . . . . V. TÆNITIS, p. 88

T
- Sori marginal, more or less confluent in a marginal band, IV. NOTHOLÆNA, p. 85
- Sori following the veinlets, simple, forked, pinnate, or variously anastomosing . . . . . III. GYMNOGRAMME, p. 84

U
- Sporangia ovate, with transverse ring at apex . . . . . **V**
- Sporangia globose without a ring . . . . XXX. OSMUNDA, p. 124

V
- Stems scandent, pinnæ palmate . . . XXVII. LYGODIUM, p. 122
- Stems not scandent . . . . . **W**

W
- Sporangia in close distichous spikes . . XXIX. SCHIZÆA, p. 123
- Sporangia in copiously branching panicles, XXVIII. ANEIMIA, p. 123

I. ACROSTICHUM L.

Sporangia spread over the whole surface of the frond or upper pinnæ, or occasionally over both surfaces. Venation and cutting various (in our species simply pinnate). Name from Gr. ἄκρος, the summit, and στιχος, a row. A tropical genus containing over 170 species.

§ CHRYSODIUM.

1. **A. aureum** L. Stipes 1°—2° long, tufted, strong, erect, glossy; fronds 2°—6° long, 1°—2° broad, upper pinnæ fertile, slightly smaller than the barren ones; texture coriaceous; areolæ small, copious, without free veinlets. Florida.

II. POLYPODIUM L.

Sori round, naked, dorsal, in one or more rows each side of midrib, or irregularly scattered. Stipes articulated to rootstock. Name from Gr. πολύς, many, and πους, ποδός, foot, alluding to the branching rootstock. The largest, most cosmopolitan genus of ferns, containing 350 or more species.

§ 1. EUPOLYPODIUM. *Veins free; fronds (in our species) pinnate.*

* *Sori large.*

1. **P. vulgare** L. Stipes 2′—4′ long, firm, erect; fronds 4′—10′ long, 1′—3′ broad, cut nearly or quite to the rachis into entire or slightly toothed, usually blunt pinnæ; veins once or twice forked. Larger fronds with their pinnæ sharply serrated and long-pointed form the *var. occidentale* Hook. New England westward to Oregon and southward to Alabama.

2. **P. falcatum** Kellogg. Stipes 5′—8′ long, stramineous; fronds 12′—15′ long, 4′—8′ broad; pinnæ numerous, tapering to a slender point, sharply serrate; sori nearest the midrib; veins with 2—4 veinlets. (*P. glycyrrhiza* D. C. Eaton.) California to British Columbia.

** *Sori smaller, often minute.*

3. **P. plumula** H. B. K. Stipes 1′—4′ long, black, slender; fronds narrowly lanceolate, 9′—18′ long, 1′—2′ broad; pinnæ numerous, narrow, entire, blunt, lower gradually reduced; surfaces naked except the black wiry rachis; veinlets forked, obscure. Florida.

4. **P. pectinatum** L. Stipes rigid 2′—6′ long; fronds elliptical-lanceolate, 1°—2½° long, 2′—6′ broad, cut to the rachis into horizontal, entire or toothed pinnæ, the lower ones much reduced; rachis naked or finely villose; veinlets pellucid, once or twice forked; sori in long rows, of medium size. Florida.

§ 2. GONIOPHLEBIUM Blume. *Veins forming ample regular areolæ (almost imperceptible in No. 5), each with a single distinct free included veinlet, bearing a sorus at its terminus.*

* *Under surface squamous.*

5. **P. polypodioides** (L.) Hitch. Rootstock creeping, covered with small brown scales; stipes 1′—4′ long, erect, densely scaly; fronds 2′—6′ long, 1′—1½′ broad, cut to the rachis into entire pinnæ; texture coriaceous; sori small; veins indistinct. (*P. incanum* Swz.) Virginia to Illinois, and southward.

6. **P. thysanolepis** A. Br. Rootstock slender, firm, densely covered with minute lanceolate scales; stipes 3′—12′ long, erect, scaly; fronds ovate, 3′—9′ long, 2′—3′ broad; pinnæ distant, ascending, blunt, dilated at base (except the lowest), thick, subcoriaceous, covered below with ciliate scales with brown centre and broad scarious border; areolæ and sori in a single series. Huachuca Mountains, Arizona (*Lemmon*), Mexico.

** *Under surface mostly smooth.*

7. **P. Californicum** Kaulf. Rootstock creeping, chaffy; stipes 2′—6′ long, stramineous when dry, naked; fronds ovate to oblong-lanceolate, 4′—9′ long, 1′—5′ broad, cut nearly or quite to midrib into finely-toothed pinnæ; texture papyraceo-herbaceous; sori large; veinlets 4—6 to each vein. (Including *P. intermedium* H. & A.) California.

8. **P. Scouleri** H. & G. Rootstock stout, creeping, scaly; stipes 2′—4′ long, erect, naked; fronds thick, 3′—12′ long, 2′—6′ broad, cut down to rachis into from 5—29 close, blunt pinnæ; texture coriaceous, fleshy when recent; sori very large; veinlets regularly anastomosing forming a single series of large areolæ. (*P. carnosum* Kellogg, *P. pachyphyllum* D. C. Eaton.) California and northward.

§ 3. PHLEBODIUM R. Br. *Veins forming ample areolæ, each with two or more distinct, free, included veinlets bearing sori on their united points.*

9. **P. aureum** L. Rootstock stout, densely scaly; stipes 1°—2° long, castaneous, naked; fronds 3°—5° long, 9′—18′ broad, cut nearly to the rachis into broad entire or slightly undulate pinnæ; areolæ copious. Florida.

§ 4. CAMPYLONEURON Presl. *Primary veins distinct from midrib to the edge, connected by parallel transverse veinlets; areolæ similar, containing two or more sori.*

10. **P. phyllitidis** L. Rootstock stout, scaly; stipes short or none; fronds simple, 1°—3° long, 1′—4′ broad, the point acute, lower part gradually narrowed; texture rigid, coriaceous; areolæ in rows of 6—12 from midrib to edge. Florida.

§ 5. PHYMATODES Presl. *Areolæ fine, copious, irregular, the free veinlets spreading in various directions; sori various in position.*

11. **P. Swartzii** Baker. Rootstock wide creeping, slender, covered with linear ferruginous scales; stipes ½′—1′ long, slender, naked; frond simple, 2′—4′ long, ⅛′—¾′ broad, narrowed gradually toward both ends, the edge entire, undulate, or slightly lobed; sori uniserial on free veinlets. (*P. serpens* Swz.) Key Largo, Florida (*Curtiss*).

III. GYMNOGRAMME Desv.

Sori oblong or linear, following the course of the veinlets and like them, simple, forked, pinnate, or variously anastomosing, without indusia. Name from Gr. *γυμνός*, naked, and *γράμμα*, line. Includes about 100 species, mostly tropical.

§ 1. EUGYMNOGRAMME. *Veins free, under surface not farinose.*

1. **G. Ehrenbergiana** Klotzsch. Rootstock creeping; stipes grayish, puberulent, 3′—6′ long; fronds 5-angled, 1′—3′ each way, hispid above, tomentose beneath, pinnate; lower pinnæ much the largest, unequally triangular, pinnate; upper pinnæ lobed or crenate. (*G. pedata* of check-lists *not* of Kaulf., *G. podophylla* Hook. in part, *G. hispida* Mett. and former edition.) Texas to Arizona.

§ 2. CEROPTERIS Link. *Fronds farinose below.*

2. **G. triangularis** Kaulf. (GOLD-FERN, GOLDEN-BACK.) Stipes densely tufted, slender, blackish-brown, polished, 6′—12′ long; fronds 2′—5′ each way, deltoid, pinnate; lower pinnæ

much the largest, triangular, bipinnatifid; upper pinnæ more or less pinnately lobed; lower surface coated with yellow or white powder, finally more or less obscured by the fruit. Arizona, California, and northward.

IV. NOTHOLÆNA R. Br. CLOAK-FERN.

Sori marginal, at first roundish or oblong, soon confluent into a narrow band, without indusium, but sometimes covered at first by the inflexed edge of the frond. Veins free. Name from Lat. *nothus*, spurious, and *læna*, a cloak, alluding to the rudimentary indusia. Includes 37 species.

§ 1. EUNOTHOLÆNA. *Fronds not farinose beneath, scaly, hairy, or tomentose.*

* *Fronds simply pinnate.*

1. **N. sinuata** (Swz.) Kaulf. Rootstock short, very chaffy; stipes 2′—4′ long, erect; fronds 6′—2° long, 1′—2′ broad; pinnæ numerous, short-stalked, roundish or ovate, entire to pinnately lobed, lower surface densely scaly. Texas to Arizona.

2. **N. ferruginea** (Desv.) Hook. Rootstock creeping, with dark rigid scales; stipes tufted, 2′—4′ long, wiry, blackish, woolly at first; fronds 8′—12′ long, ½′—1′ broad, narrowly lanceolate; pinnæ numerous, ovate, pinnatifid, hairy above, densely tomentose beneath, the wool at first whitish, but becoming ferruginous. (*N. rufa* Presl.) Texas to Arizona.

** *Fronds bi—quadripinnate.*

† *Fronds silky-hairy above.*

3. **N. Parryi** D. C. Eaton. Rootstock short, scaly; stipes 2′—4′ long, dark brown, pubescent with whitish jointed hairs; fronds 2′—4′ long, oblong-lanceolate, tripinnate, lower pinnæ distinct; segments crowded, roundish-obovate, one line broad, densely covered above with entangled white hairs, beneath with a heavier pale-brown tomentum. Utah, California, Arizona.

4. **N. Newberryi** D. C. Eaton. (COTTON-FERN.) Rootstock with very narrow dark bristly scales; stipes tufted, 3′—5′ long, blackish-brown, woolly when young, with pale-ferruginous tomentum; fronds 3′—5′ long, lanceolate-oblong, covered most densely beneath with fine whitish hairs, tri—quadripinnate; ultimate segments roundish-obovate, ⅓″—½″ broad. California.

†† *Fronds slightly hispid above.*

5. **N. Aschenborniana** Klotzsch. Rootstock short, creeping; stipes tufted, 2′—3′ long, wiry, ebeneous, densely scaly; fronds 4′—10′ long, 2′—3′ broad, oblong-lanceolate, tripinnatifid; pinnæ lanceolate, cut into linear-oblong, crenate or pinnatifid pinnules; upper surface pale-green, the lower densely matted with linear, ciliate, bright ferruginous scales, beneath which it is subfarinose; sori black. Huachuca Mts., Arizona (*Lemmon*), Texas (*Drummond*), Mexico.

§ 2. CINCINALIS Desv. *Fronds farinose, with white or yellow powder (in one species naked).*

* *Fronds farinose below.*

† *Fronds deltoid or pentagonal, barely bipinnate.*

6. **N. candida** (M. et G.) Hook. Rootstock creeping, with rigid, nearly black scales; stipes tufted 3′—6′ long, wiry, black and shining; fronds rather shorter than stipe, deltoid-ovate, pinnate; lowest pinnæ with the lowest inferior pinnules elongate and again pinnatifid, the three or four succeeding pairs lanceolate, pinnatifid into oblong segments, the uppermost pinnæ like the segments of the lower; upper surface green; lower surface whitish farinose; margin slightly revolute. (*N. sulphurea* J. Sm., *N. pulveracea* Kunze.) Southwestern Texas (*Reverchon*); New Mexico (*Wright*).

7. **N. cretacea** Liebm. Rootstock short, oblique, the scales rigid, lanceolate, with a narrow membranous margin; stipes 2′—7′ long, brownish, wiry, scaly when young; fronds 1′—2′ long, broadly deltoid-ovate to pentagonal, tri—quadripinnatifid at base, gradually simpler above; ultimate segments oblong or triangular-oblong, numerous, crowded; upper surface more or less covered with deciduous glands; lower surface copiously farinose with yellow or whitish powder except on the prominent dark-brown rachises; margins more or less recurved, not covering the sporangia; spores globose, black. (*N. Californica* D. C. Eaton.) San Diego County, California (*Cleveland, Parish*); Arizona (*Parry, Lemmon*).

8. **N. Hookeri** D. C. Eaton. Rootstock short, densely covered with rigid lanceolate dark-brown scales; stipes tufted, 4′—8′ long, reddish-brown, wiry, shining; fronds 2′—3′ each way, nearly pentagonal, composed of three divisions; the mid-

dle one slightly stalked, pinnatifid into a few toothed segments, the second pair larger than the first; side divisions bearing a single large pinnatifid basal segment on the lower side, and above it smaller ones like those of the upper side; lower surface covered with pale, yellow powder. Texas to Arizona.

†† *Fronds lanceolate or linear-oblong, bipinnate or tripinnatifid.*

9. **N. Grayi** Dav. Stipes tufted, 1′—4′ long, chestnut-brown, with nearly black, rigid scales below, paler deciduous scales above; fronds 2′—6′ long, ¾′—1¼′ wide, the upper surface sparingly, the lower thickly, covered with white powder; pinnæ short-stalked, unequally triangular-ovate, deeply pinnatifid or divided into one or two pairs of oblong pinnatifid, obtuse pinnules, the remaining portion obliquely pinnatifid with alternate segments; sori brown. Southeastern Arizona to Texas.

10. **N. Schaffneri** (Fourn.) Unde. Rootstock short, stout, with black pectinate scales; stipes 1′—2′ long, brownish-black, with narrow, rigid scales; fronds lanceolate, 5′—8′ long, bi—tripinnatifid, the pinnules numerous, narrow, with narrow dark scales underneath; sori continuous, brown or black. (*N. Nealleyi* Seaton, *Aleuritopteris Schaffneri* Fourn.) Western Texas (*Nealley*).

11. **N. Lemmoni** D. C. Eaton. Rootstock short, scaly, with narrow, rigid, dark-brown chaff; stalks reddish-brown, 4′—6′ long, chaffy only at base with wider scarious-margined scales; fronds 6′—9′ long, 1′—1½′ wide, with numerous deltoid or ovate pinnæ, the lowest a little shorter than the middle ones; upper surface smooth, the lower with white or yellowish powder; sori in a narrow submarginal line. Arizona.

††† *Fronds deltoid-ovate, tri—quadripinnate at base.*

12. **N. nivea** Desv. Rootstock short, chaffy, with narrow scales; stipes tufted, 4′—6′ long, wiry, black and polished;

fronds 3′—6′ long, 1½′—2′ broad, ovate, lanceolate, triangular-ovate or deltoid, tripinnate; primary pinnæ mostly opposite, the rachises nearly straight; pinnules long-stalked; segments roundish, nearly as broad as long, terminal ones larger, entire or 3-lobed; upper surfaces green, smooth, lower densely coated with pure white powder; sori brown, often descending the free veins half-way to the midvein. Arizona, New Mexico.

Var. **dealbata** (Pursh) Dav. Segments more numerous, longer than broad, terminal ones rarely lobed. (*N. dealbata* Kunze and former editions. *Cheilanthes dealbata* Pursh.) Upper Missouri to New Mexico and Arizona.

13. **N. Fendleri** Kunze. Stipes densely tufted, dark-brown, 3′—5′ long; rachis and all its branches zigzag and flexuous; fronds broadly deltoid-ovate, 3′—5′ each way, quadripinnate below, gradually simpler above; pinnæ alternate; ultimate pinnules oval or elliptical, simple or 3-lobed. Colorado, New Mexico, Arizona.

** *Fronds naked below.*

14. **N. tenera** Gillies. Stipes tufted, brownish, smooth and shining; fronds 3′—4′ long, ovate-pyramidal, bi—tripinnate; pinnæ mostly opposite, distant, the lower ones somewhat triangular; ultimate pinnules ovate, often sub-cordate, obtuse, smooth, and naked on both surfaces; possibly only a form of *N. nivea*. Southern Utah, California.

V. TÆNITIS Swz.

Sori linear, but the line sometimes interrupted, central or sub-marginal. Veins reticulate. Name from Lat. *tænia*, a band. Includes five species, all tropical.

1. **T. lanceolata** (L.) R. Br. Rootstock creeping; stipes 1′—2′ long; fronds simple, 6′—13′ long, ½′—¾′ broad, tapering both ways, the edge entire or sometimes crisped, midrib prominent; veins immersed, the exterior free and clubbed at their apices; sori ante-marginal, in a continuous line near the apex. (*Lingua cervina* Plum., *Pteris lanceolata* L., *Pteropsis lanceolata* Desv., *Neurodium lanceolatum* Fee.) Old Rhodes Key, Florida (*Curtiss*).

VI. VITTARIA Sm. GRASS-FERN.

Sori linear, continuous, in two-lipped marginal grooves or in slightly intramarginal lines, with the unaltered edge of the frond produced beyond and often rolled over them, but without special indusia. Fronds narrow, grass-like. Veins free. Name from Lat. *vitta*, a fillet or head-band. A tropical genus containing 13 species.

§ TÆNIOPSIS J. Sm.

1. **V. lineata** (L.) Sm. Fronds 6′—18′ long, 1″—5″ broad, narrowed gradually downward to a stout compressed stem, the edge often reflexed; sori in a broad intramarginal line in a slight furrow, the edge of the frond at first wrapped over it. (*V. angustifrons* Michx.) Florida.

VII. ADIANTUM L. MAIDENHAIR.

Sori marginal, short, covered by a reflexed portion of the more or less altered margin of the frond, which bears the sporangia on its under side from the approximated tips of free, forking veins. Name from Gr. α, without, and διαίνω, to wet, alluding to the smooth foliage. Includes over 80 species, mostly from Tropical America.

§ EUADIANTUM.

* *Fronds at least bipinnate, pinnules flabellate or cuneate.*

† *Fronds smooth.*

1. **A. capillus-veneris** L. (VENUS' HAIR.) Stipes nearly black, polished, very slender; fronds ovate-lanceolate, delicate, bipinnate, the upper half or third simply pinnate; pinnules and upper pinnæ wedge-obovate or rhomboid, rather long-stalked, the upper margin rounded and more or less incised, crenate, or acutely dentato-serrate, except where the margin is recurved to form the lunulate separated indusia. Virginia, Kentucky, and Florida to Utah and California.

2. **A. tenerum** Swz. Stipes 1° high, erect, glossy; fronds 1°—3° long, 9′—18′ broad, deltoid, tri—quadripinnate; pinnules articulated to their petioles, falling off at maturity, cuneate, the upper edge rounded or somewhat angular, broadly, often rather deeply lobed; sori numerous, roundish, or transversely oblong. Florida.

3. **A. emarginatum** Hook. Stipes rather stout, nearly black, polished; fronds ovate or deltoid-pyramidal, bi—tripinnate; pinnules and upper pinnæ ample, smooth, or nearly so, rounded or even reniform, upper margin rounded, slightly incised; sori 2—5, transversely linear-oblong, subcontinuous. (*A. tenerum* Torr.) California and northward.

†† *Fronds pilose, with whitish hairs.*

4. **A. tricholepis** Fee. Stipes smooth, polished, deep black; fronds oval; pinnules roundish, moderately long-stalked; sori few (3—7), of unequal size; indusia very velvety. (*A. dilatatum* Nutt.) Western Texas.

** *Fronds dichotomously forked, with numerous pinnæ springing from the upper side of the two branches.*

5. **A. pedatum** L. Stipes 9′—15′ long, dark chestnut-brown, glabrous; fronds nearly circular in outline; central pinnæ 6′—9′ long, 1′—2′ broad; pinnules triangular-oblong, short-stalked; sori roundish or transversely oblong. North Carolina to California and northward.

Var. **rangiferinum** Burgess. Pinnules longer-stalked and deeply cleft into narrow-toothed lobes on the upper side. Mount Findlayson, British Columbia.

VIII. PTERIS L. Brake.

Sori marginal, linear, continuous, occupying a slender filiform receptacle which connects the tips of the free veins. Indusium membranous, formed of the reflexed margin of the frond. Name from Gr. πτέρις, a fern, from πτερόν, a wing, alluding to the prevalence of pinnate fronds. A cosmopolitan genus containing 103 species.

§ 1. Eupteris. *Veins free, stipes tufted, indusium single.*

* *Lower pinnæ linear, undivided.*

1. **P. longifolia** L. Stipes 6′—12′ long, clothed more or less below with pale-brown scales; fronds 1°—2° long, 4′—9′ broad, oblong-lanceolate; pinnæ sessile, 2″—5″ broad, linear, entire; veins close and fine, usually once branched; indusium yellowish-brown. Florida.

** *Lower pinnæ forked or slightly pinnate below.*

2. **P. Cretica** L. Stipes 6′—12′ long, erect, stramineous or pale-brown; fronds 6′—12′ long, 4′—8′ broad, lateral pinnæ usually in 2—6 opposite sessile pairs, the sterile ones considerably the broadest and spinulose-serrate, the lower pairs often cleft nearly to the base, into two or three linear pinnules; veins fine, parallel, simple or once forked; indusium pale. Florida.

3. **P. serrulata** Linn. f. Stipes 6′—9′ long, naked, pale or brownish; fronds 9′—18′ long, 6′—9′ broad, ovate, bipinnatifid, the main rachis margined with a wing which is 1″—2″ broad at the top and grows narrower downwards; pinnæ in six or more distinct opposite pairs, upper ones simple, the lower ones with several long linear pinnules on each side, the edge of the barren ones spinulose-serrate; veins simple or once forked. Alabama (*Mohr*), Macon, Georgia (*Farnell*).

§ 2. PÆSIA St. Hilaire. *Veins free, rootstock creeping, stipes sub-distant, indusium more or less double.*

4. **P. aquilina** L. Rootstock stout, wide-creeping, subterranean; stipes 1°—2° high, erect, stramineous or brownish; fronds 2°—4° long, 1°—3° wide, ternate, the three branches each bipinnate; upper pinnules undivided, the lower more or less pinnatifid. North America everywhere.

Var. **caudata** (L.) Hook. Pinnules sometimes linear and entire, or with less crowded segments than the type and the terminal lobe linear and entire. (*P. caudata* L.) New Jersey to Florida and Texas.

Var. **lanuginosa** (Bory) Hook. Fronds silky-pubescent, tomentose, especially on the under surface; otherwise as in the typical form. (*P. lanuginosa* Bory.) Utah, California and northward.

IX. CHEILANTHES Swz. LIP-FERN.

Sori terminal or nearly so on the veins, at first small and roundish, afterwards more or less confluent. Indusium formed of the reflexed margin of the frond, roundish and distinct, or more or less confluent. Veins free. Name from Gr. χεῖλος, a lip, and ἄνθος, flower, alluding to the lip-like indusia. A genus of 65 species of tropical and temperate zones.

§ 1. ADIANTOPSIS Fee. *Indusia distinct, roundish, confined to the apex of a single veinlet.*

1. **C. Californica** (Nutt.) Mett. Rootstock short, creeping, chaffy; stipes densely tufted, dark-brown, glossy, 4′—8′ long; fronds 4′ or less each way, broadly deltoid-ovate, smooth on both surfaces, quadripinnatifid; lower pinnæ largest, triangular; upper ones gradually smaller and simpler; ultimate segments lanceolate, acute, incised or serrate; indusia membranous. (*Aspidotis Californica* Nutt., *Hypolepis Californica* Hook.) California.

2. **C. Pringlei** Dav. Rootstock slender, creeping, clothed with linear-lanceolate scales; stipes 1½′—4½′ long, reddish or chestnut brown, scaly at base and sparingly above; fronds 1′—2½′ long, nearly as broad, triangular or ovate-deltoid, bi—tripinnately divided into 5—7 pairs of pinnæ, opposite and spreading in the smaller sterile fronds, alternate and erecto-patent in the larger fertile fronds, naked, dark-green; pinnæ ⅝′—1⅛′ long, the lower unequally deltoid or ovate, bipinnate, the uppermost oblong, pinnate or deeply pinnatifid; pinnules ovate or oblong, pinnately divided or cleft into oblique segments, which are again deeply cleft into cuneate, strap-shaped divisions, those of the largest segments again deeply cut into narrow, obtuse, cuneate lobes, the recurved tips in fertile fronds forming distinct herbaceous involucres with entire or slightly crenulate margins; sori one to each ultimate lobe on the apex of a free veinlet. South-eastern Arizona (*Pringle*).

§ 2. EUCHEILANTHES. *Indusia more or less confluent, usually extending over the apices of several veinlets, but not continuous all round the segments; segments mostly flat, not bead-like.*

* *Segments of the frond smooth.*

† *Pinnæ few, not more than 5—6 pairs.*

3. **C. Wrightii** Hook. Stipes castaneous, slightly chaffy at base, 1′—2′ long; fronds 2′—3′ long, ovate-oblong, tripinnatifid, segments more or less incised; indusium sub-continuous or interrupted, similar to frond in texture. Western Texas to Arizona.

†† *Pinnæ numerous.*

4. **C. microphylla** Swz. Rootstock short, creeping;

stipes dark-brown, glossy, rusty pubescent on the upper side, 4′—6′ long; fronds 4′—10′ long, ovate-lanceolate, bi—tripinnate; pinnæ lanceolate, the lowest ones usually largest and more deltoid; pinnules oblong or deltoid-ovate, deeply incised or pinnate; indusium similar in texture to frond, interrupted or subcontinuous. Florida, New Mexico.

5. **C. Alabamensis** (Buckl.) Kunze. Rootstock creeping, with slender brown scales; stipes black with scanty ferruginous wool; fronds 2′—10′ long, narrowly lanceolate, bipinnate; pinnæ close, ovate-lanceolate, the lowest ones not enlarged, usually smaller than those above; pinnules mostly acute, often auriculate on the upper side at the base; indusia pale, membranous, interrupted only by the incising of the pinnules. (*Pellæa Alabamensis* Baker, *Pteris Alabamensis* Buckley.) Virginia, Alabama, Tennessee to Texas and Arizona (*Lemmon*).

*** Segments of the frond glandular viscid.*

6. **C. viscida** Dav. Stipes 3′—5′ long, wiry, blackish, chaffy at the base with narrow ferruginous scales; fronds 3′—5′ long, ½′—1′ broad, narrowly oblong, pinnate, with 4—6 distant pairs of nearly sessile, deltoid, bipinnatifid pinnæ; segments toothed, minutely glandular and everywhere viscid; teeth of segment recurved, forming indusia. California.

**** Fronds somewhat hairy and glandular, not tomentose.*

† Fronds deltoid-ovate; stipes stramineous.

7. **C. leucopoda** Link. Stipes 3′—10′ long, stout, chaffy at base; fronds 2′—7′ long, deltoid-ovate, quadripinnate at base, gradually simpler above, everywhere glandular-puberulent; lowest pair of pinnæ unequally deltoid-ovate, upper ones oblong; pinnules short-stalked; ultimate pinnules divided into minute rounded lobules, strongly revolute when fertile. Texas.

†† Fronds ovate-lanceolate; stipes brownish.

8. **C. lanosa** (Michx.) Watt. Stipes tufted, 2′—4′ long, chestnut-brown; fronds 4′—9′ long, 1′—2′ broad, tripinnatifid; pinnæ somewhat distant, lanceolate-deltoid; segments more or less thickly covered with acute hairs; sori copious; indusia formed of the ends of roundish or oblong lobes. (*Nephrodium lanosum* Michx. *C. vestita* Swz.) New York to Kansas and Georgia.

9. **C. Cooperæ** D. C. Eaton. Stipes densely tufted, fragile,

hairy with straightish nearly white articulated hairs, which are usually tipped with a glandular and viscid enlargement; fronds 3′—8′ long, bipinnate, the pinnæ rather distant, oblong-ovate; pinnules roundish-ovate, crenate and incised, the ends of the lobules forming herbaceous indusia. California.

§ 3. PHYSAPTERIS Presl. *Ultimate segments minute, bead-like; indusium usually continuous all round the margin; fronds (in our species) bi—quadripinnate, the lower surface scaly or tomentose or both.*

Fronds hairy or tomentose beneath, not scaly.

† *Upper surface naked or nearly so.*

10. **C. gracillima** D. C. Eaton. (LACE-FERN.) Stipes densely tufted, 2′—6′ long, dark-brown; fronds 1′—4′ long, narrowly ovate-lanceolate, bipinnate; pinnæ numerous, crowded, pinnately divided into about nine oblong-oval pinnules, at first slightly webby above, soon smooth, heavily covered beneath with pale-ferruginous matted wool; indusia yellowish-brown, formed of the continuously curved margin. (*C. vestita* Brack.) California, Oregon, British Columbia, Idaho.

11. **C. lendigera** (Cav.) Swz. Rootstock creeping, covered with narrow scales; stipes rather distant, 4′—8′ long, at first loosely tomentose, at length nearly smooth; fronds 4′—8′ long, ovate-oblong, tri quadripinnate; ultimate pinnules small, cuneate-obovate, pouch-like from the recurved margins, green above, hairy below. Huachuca Mts., Arizona (*Lemmon*).

‡‡ *Upper surface decidedly pubescent.*

‡ *Stipes tomentose or smooth.*

12. **C. gracilis** (Fee) Mett. Stipes densely tufted, slender, at first clothed with woolly hairs, at length nearly smooth; fronds 2′—4′ long, ovate-lanceolate, tripinnate or tripinnatifid, rarely bipinnate; pinnæ deltoid below, oblong-ovate above, the lowest distant; ultimate pinnules minute, the terminal one slightly largest, crowded; upper surface scantily tomentose, the lower densely matted with whitish-brown, woolly hairs; indusia narrow, formed of the unchanged margin. (*C. lanosa* Eaton, *C. vestita* Hook. *p. p.*, *C. lanuginosa* Nutt, *Myriopteris gracilis* Fee.) Illinois to Texas, Arizona, and British America.

13. **C. tomentosa** Link. Stipes tufted, 4′—6′ long, rather

stout, covered with pale-brown tomentum; fronds 8′—15′ long, oblong-lanceolate, everywhere but especially beneath tomentose with slender, brownish-white, obscurely articulated hairs, tripinnate; pinnæ and pinnules ovate-oblong; ultimate pinnules ½″—¾″ long, the terminal ones twice as large; indusium pale, membranous, continuous. (*C. Bradburii* Hook.) Virginia to Missouri, Texas, and Arizona.

‡‡ *Stipe and rachises covered with very narrow scales.*

Var. **Eatoni** Dav. Differs from the type mainly in having the rachises scaly; characters scarcely sufficient to keep it distinct. (*C. Eatoni* Baker and former editions.) Arizona.

14. **C. fibrillosa** Dav. Plant 3′—6′ high; rootstock forming dense, entangled clumps of short rhizomes, clothed with dark linear-lanceolate scales, passing gradually into lighter-brown scales, mixed with coarse fibres and tomentum at the base of the stipes; stipes 2′—3′ long, chestnut-brown, terete, at first tomentose with fibrous scales and wool, becoming smooth with age; fronds 2′—3′ long, ¾′—1½′ wide, tripinnate, loosely covered with deciduous tomentum, that along the rachises beneath persistent, tawny, mixed with coarse fibres. (*C. lanuginosa*, var. *fibrillosa* Dav.) San Jacinto Mountains, California (*Parish*).

15. **C. Parishii** Dav. Rootstock creeping, short, clothed with deep-brown linear-lanceolate scales, with darker nearly black mid-nerves; stipes 2′—3′ long, approximate, light to dark-brown, clothed at base with scales similar to those on the rootstock, passing gradually into broader pale-brown or nearly white nerveless scales, with more or less deciduous, slender, pale scales and chaff above; fronds 3′—4′ long, 1′—1¼′ broad, oblong-lanceolate, tri—quadripinnate, with both surfaces scantily clothed with a coarse tomentum; pinnæ alternate, oblong-ovate, obtuse, the lowermost somewhat distant; segments roundish, the terminal ones largest and three-lobed; indusia very narrow, only partially enclosing the sori. San Diego Co., California (*Parish*).

** *Fronds covered beneath with imbricated scales, not tomentose.*

16. **C. Fendleri** Hook. Stipes 2′—5′ long, chaffy with minute slender scales; fronds 3′—4′ long, ovate-lanceolate, tripinnate; scales of primary rachis like those of stipe, those of

secondary and ultimate rachises larger, broadly-ovate, entire or nearly so, usually edged with white, imbricate and overlapping the ($\frac{1}{4}$''—$\frac{1}{3}$'' broad) sub-globose ultimate segments; these are naked above, and commonly bear at their centre a single broad scale; indusium formed of the much incurved margin. Texas and Colorado to California.

17. **C. Clevelandii** D. C. Eaton. Stipes scattered, 2'—6' long, dark-brown, scaly when young, but at length nearly smooth; fronds 4'—6' long, ovate-lanceolate, tripinnate, smooth above, deep fulvous-brown below from the dense covering of closely imbricate, ciliate scales growing on the ultimate segments as well as on the rachises; segments nearly round, $\frac{1}{8}$''—$\frac{1}{2}$'' broad, the terminal ones larger, margin narrowly incurved. California.

**** Under surface both tomentose and scaly.*

18. **C. myriophylla** Desv. Rootstock very short, scaly; stipes tufted, 2'—6' high, castaneous, covered with pale-brown scales and woolly hairs intermixed; fronds 3'—8' long, oblong-lanceolate, tri—quadripinnatifid, smooth or pilose above, beneath matted-tomentose and densely clothed with pale-brown, narrowly ovate-lanceolate, ciliate scales, those of the ultimate segments with long, tortuous cilia; pinnæ deltoid-ovate, narrower upwards; ultimate segments minute, $\frac{1}{2}$'' broad, crowded, innumerable, the margin unchanged, much incurved. Very variable. (*C. elegans* Desv., *C. villosa* Dav.) Texas to Arizona.

19. **C. Lindheimeri** Hook. Rootstock long, slender, chaffy; stipes scattered, 4'–7' high, blackish-brown, at first covered with scales and woolly hairs; fronds 3'—8' long, ovate-lanceolate, tri—quadripinnate; ultimate segments $\frac{1}{4}$'' long, crowded; upper surface white tomentose, lower surface very chaffy, those of the midribs ciliate at base, those of the segments more and more ciliate, passing into entangled tomentum. Western Texas to Arizona.

§ 4. ALEURITOPTERIS Fee. *Indusia more or less confluent; fronds farinose below.*

20. **C. argentea** (Gmel.) Kunze. Stipes tufted, 3'—6' long, castaneous; fronds 3'—4' long, 2' broad, deltoid, bi—tripinnatifid; lower pinnæ much the largest, cut nearly to the rachis; rachis polished like the stipe; upper surface naked, lower thick-

ly covered with white powder; sori numerous, very small. Alaska.

X. CRYPTOGRAMME R. Br. Rock-brake.

Sporangia on the back or near the ends of the free veins, forming oblong or roundish sori, which are at length confluent, and cover the back of the pinnules. Indusium continuous, formed of the membranous, somewhat altered margin of the pinnule, at first reflexed along the two sides and meeting at the midrib, at length opening out flat. Name from Gr. *κρυπτός*, concealed, and *γράμμα*, line, alluding to the concealed fructification. A boreal genus of two species.

1. **C. acrostichoides** R. Br. Stipes densely tufted, stramineous; fronds dimorphous, sterile ones on shorter stalks, tri—quadripinnatifid, with toothed or incised segments; fertile ones long-stalked, less compound, with narrowly elliptical or oblong-linear pod-like segments. (*C. crispa, forma Americana* Hook., *Allosorus acrostichoides* Spreng.) Lake Superior, Colorado to California and northward.

XI. PELLÆA Link. Cliff-brake.

Sori intramarginal, terminal on the veins, at first dot-like or decurrent on the veins, at length confluent laterally, forming a marginal line. Indusium commonly broad and membranous, formed of the reflexed margin of the fertile segment. Name from Gr. *πελλός*, dusky, alluding to the dark-colored stipes. Includes 55 species.

§ 1. Cheiloplecton Fee, Baker. *Texture herbaceous or subcoriaceous, veins clearly visible, indusium broad, in most of the species rolled over the sorus till maturity.*

1. **P. Breweri** D. C. Eaton. Stipes densely tufted, covered with narrow, crisped, fulvous chaff; fronds 2′—6′ long, simply pinnate, the pinnæ short-stalked, 6—8 pairs, membranous, mostly 2-parted, the upper segment larger; segments obtuse, in the fertile frond narrower; indusium continuous, pale; veins repeatedly forked. Colorado to California and southward.

2. **P. gracilis** (Michx.) Hook. Stipes scattered, 2′—3′ long, stramineous or pale-brown; fronds 2′—4′ long, 1′—2′ broad, ovate, bi—tripinnatifid; pinnæ lanceolate-deltoid, cut to the

rachis into a few broad, blunt, slightly-lobed pinnules; texture thinly herbaceous, flaccid; indusium broad, continuous, membranous; veins of the fertile fronds mostly only once forked. (*Allosorus crispus*, var. *Stelleri* Milde, *A. gracilis* Presl, *Pteris gracilis* Michx., *P. Stelleri* Gmelin.) Labrador to Pennsylvania, Illinois, Colorado, and northward.

§ 2. ALLOSORUS Baker. *Texture coriaceous, the veins not perceptible; indusium broad, conspicuous.*

* *Pinnules or segments obtuse or barely acute.*

† *Fronds pinnate or bipinnate.*

3. **P. atropurpurea** (L.) Link. Stipes tufted, 2′—6′ long, dark-purple; fronds 4′—12′ long, 2′—6′ broad, lanceolate or ovate-lanceolate, simply pinnate or bipinnate below; pinnules and upper pinnæ 1′—2′ long, ¼′ broad or less, nearly sessile, smooth; indusium formed of the slightly altered incurved edge of the pinnules. (*Allosorus atropurpureus* Kunze, *Pteris atropurpurea* L., *Platyloma atropurpurea* J. Sm.) Arizona, New Mexico, Texas to Vermont and northward.

4. **P. aspera** (Hook.) Baker. Stipes slender, 2′—3′ long, with scurfy pubescence, fronds 4′—6′ long, oblong-lanceolate, bipinnate; pinnæ and pinnules deltoid-lanceolate or oblong, pinnules next to main rachis often lobed; all of them rough on both surfaces with short harsh hairs. (*Cheilanthes aspera* Hook.) Western Texas and New Mexico.

†† *Fronds bi—quadripinnate, ultimate segments oval or cordate.*

5. **P. andromedæfolia** (Kaulf.) Fee. Stipes scattered, pale-brown, 2′—12′ long; fronds 6′—12′ long, 3′—6′ broad, ovate, bi—quadripinnate, usually tripinnate; pinnæ rather distant, spreading; ultimate pinnules 2″—5″ long, oval, slightly cordate, coriaceous, the margin of the fertile ones sometimes revolute to the midrib; veins numerous, parallel. (*Allosorus andromedæfolius* Kaulf., *Pteris andromedæfolia* Kaulf.) California.

6. **P. pulchella** (M. et G.) Fee. Stipes tufted, 3′—8′ long, chaffy at base, nearly black; fronds 3′—9′ long, 1′—5′ broad, triangular-ovate, quadripinnate below, gradually simpler above; lower pinnæ deltoid, narrowly triangular above; ultimate pinnules numerous, 1″—3″ long, oval or often cordate-ovate, stalked, coriaceous, smooth, the edges often much reflexed.

(*Allosorus pulchellus* Mart. and Gale.) Western Texas and New Mexico.

††† *Fronds tri—quadripinnatifid; segments linear-oblong; secondary rachises margined.*

7. **P. marginata** (Hook.) Baker. Stipes, 3′ -9′ long, castaneous, shining, slightly fibrillose at the base; fronds 4′—6′ long, nearly as broad, deltoid; the lower pinnæ much the largest; indusium broad, continuous, the margins slightly erose; texture chartaceous. (*Cheilanthes marginata* Hook.) Huachuca Mts., Arizona (*Lemmon*).

** *Pinnules mucronulate or decidedly acute.*

† *Fronds narrowly linear in outline, usually bipinnate.*

8. **P. ternifolia** (Cav.) Link. Stipes tufted, nearly black, 2′—6′ long, fronds 4′—10′ long, narrowly linear; pinnæ usually 9—15 pairs, all but the uppermost trifoliate; segments commonly linear, slightly mucronate, coriaceous, sessile or the middle one indistinctly stalked, the edges much inflexed in fertile fronds; indusium broad. (*Pteris ternifolia* Cav.) Western Texas.

9. **P. brachyptera** (Moore) Baker. Stipes 2′—8′ long, purplish-brown; fronds 3′—8′ long, narrow in outline from the ascending secondary rachises, bipinnate; pinnules crowded, 2″—5″ long, oblong-linear, simple or trifoliate, acute or mucronulate; margins inflexed to the midrib in fertile fronds. (*P. ornithopus, var. brachyptera* D. C. Eaton, *Platyloma bellum et P. brachypterum* Moore.) California.

†† *Fronds broader, lanceolate to ovate, bi—tripinnate.*

10. **P. ornithopus** Hook. Stipes tufted, 3′—8′ long, rather stout, dark-brown; fronds very rigid, 3′—12′ long, 2′—3′ broad, broadly deltoid-lanceolate, bi—tripinnate; primary pinnæ spreading or obliquely ascending, linear, bearing 4—16 pairs of trifoliate (varying from simple to 5—7 foliate) mucronulate pinnules, 1½″—2″ long; margins inflexed to midrib in fertile fronds. (*Allosorus mucronatus* D. C. Eaton.) California.

11. **P. Wrightiana** Hook. Rootstock short, thick, densely chaffy; stipes crowded, purplish-brown, 4′—6′ long; fronds 3′—10′ long, 1′—3′ broad, lanceolate to deltoid, trifoliate at apex,

bipinnate below; pinnæ short with 1—2 pairs of long narrow pinnules besides the terminal one; mucro short, with margin broad and cartilaginous; margins of fertile fronds inflexed to the midrib. Very variable; forms with fronds decreasing to simply pinnate at the apex, and longer but less broadly winged mucro form *var. longimucronata* Dav. (*P. longimucronata* Hook.); forms with pinnules densely crowded are var. *compacta* Dav. Colorado and Texas to California.

12. **P. densa** (Brack.) Hook. Rootstock slender, chaffy with blackish scales; stipes densely tufted, wiry, very slender, castaneous, 3′—9′ long; fronds ovate or triangular-oblong, 1′—3′ long, densely tripinnate; segments 3″—6″ long, linear, nearly sessile, sharp pointed or mucronate, in the fertile fronds entire, with the margin narrowly recurved; in the rare sterile fronds sharply serrate, especially toward the apices. (*Onychium densum* Brack.) Utah (*Jones*), and Wyoming to California, Oregon, and northward; Mt. Albert, Gaspé, Quebec (*Allen*).

§ 3. PLATYLOMA J. Sm., Baker. *Texture coriaceous, the veins usually hidden, the ultimate segments broad and flat, the indusium so narrow as to be soon hidden by the fruit.*

13. **P. Bridgesii** Hook. Stipes 2′—6′ long, tufted, castaneous; fronds 4′—6′ long, 1′ or more broad, simply pinnate; pinnæ 5—18 pairs, mainly opposite, nearly sessile, glaucous green, coriaceous, rounded or cordate at the base; indusium narrow, formed of the whitish margin of the pinna, soon flattened out exposing the broad sorus. California.

14. **P. flexuosa** (Kaulf.) Link. Rootstock creeping, slender; stipes reddish, passing into a more or less flexuous or zigzag rachis; fronds 6′ -30′ long, ovate-oblong, bi—tripinnate; secondary and tertiary rachises usually deflected and zigzag, rusty puberulent or nearly smooth; pinnæ mostly alternate; ultimate pinnules 5″—10″ long, roundish-ovate, or sub-cordate, smooth; margins at first reflexed, soon flattened out. (*Allosorus flexuosus* Kaulf.) Western Texas to California.

15. **P. intermedia** Mett. Rootstock long, wide creeping, slender, chaffy; stipes scattered, 4′—6′ long, pinkish-stramineous, smooth; fronds 5′—10′ long, 3′—8′ wide, ovate-bipinnate; pinnæ nearly opposite, remote; pinnules 2—6 pairs, petiolate, sub-coriaceous, oval or cordate-ovate; veins obscure; ra-

chises often pubescent. Huachuca Mountains, South Arizona (*Lemmon*) Texas (*Nealley*).

XII. CERATOPTERIS Brong. Floating-fern.

Sori placed on two or three veins which run down the frond longitudinally, nearly parallel with both the edge and midrib. Sporangia scattered on the receptacles, sessile, sub-globose, with a complete, partial, or obsolete ring. Indusia formed of the reflexed margins of the frond, those of opposite sides meeting at the midrib. Name from Gr. κέρας, horn, and πτέρις, a fern. Contains a single tropical species.

1. **C. thalictroides** (L.) Brong. Stipes tufted, inflated, filled with large air-cells; fronds succulent in texture, the sterile ones floating in quiet water, simple or slightly divided when young, bi—tripinnate when mature; fertile ones bi—tripinnate; ultimate segments pod like. Southern Florida.

XIII. LOMARIA Willd.

Sori in a continuous band next the midrib of the contracted pinnæ of the fertile frond, covered till mature by an elongate indusium, either formed of the recurved and altered margin of the pinna or sub-marginal and parallel to the margin. Veins of sterile frond oblique to the midrib, simple or forked and free. Fronds mostly elongate, of two kinds, the sterile foliaceous, the fertile commonly much contracted. Name from Gr. λόμα, a fringe. Principally south temperate, containing 45 species.

§ Eulomaria.

1. **L. spicant** (L.) Desv. (Deer-fern.) Rootstock short very chaffy; fronds tufted, erect, sterile ones nearly sessile, narrowly linear-lanceolate, 8′—24′ long, 1′—3′ wide, tapering to both ends, cut to the rachis into oblong or oblong-linear closely set segments, the lower ones gradually diminishing to minute auricles; fertile fronds sometimes three feet high, long-stalked, pinnate; pinnæ somewhat fewer and more distant, longer and much narrower than in the sterile frond; indusia distinctly intramarginal. (*Osmunda spicant* L., *Blechnum boreale* Swz.) California, Oregon, and northward.

XIV. BLECHNUM L.

Sori linear, continuous or nearly so, parallel with the midrib and usually contiguous to it. Indusium membranous, distinct from the edge of the frond. Veins usually free. Name from Gr. *βλεχνον*, an old name for some kind of fern. A tropical and south temperate genus, containing 19 species.

§ EUBLECHNUM.

1. **B. serrulatum** Richard. Stipes 6′—12′ long, stout, erect, nearly naked; fronds oblong-lanceolate, 1°—1½° long, 3′—6′ broad, with 12—24 pairs of distinct linear-oblong pinnæ, the margins finely incised; texture coriaceous; veins very fine and close; fertile pinnæ narrower. (*Blechnum angustifolium* Willd.) Florida.

XV. WOODWARDIA Sm. CHAIN-FERN.

Sori oblong or linear, sunk in cavities in the frond, arranged in a chain-like row parallel to the midribs of the pinnæ and pinnules and near them. Indusium sub-coriaceous, fixed by its outer margin to the fruitful veinlet and covering the cavity like a lid. Veins more or less reticulate. Named for *Thomas J. Woodward*, an English botanist. Contains six species, mostly north temperate.

§ 1. EUWOODWARDIA. *Fronds uniform, the veins forming at least one series of areolæ between the sori and margins.*

1. **W. radicans** (L.) Sm. Caudex stout, erect, rising a little above the ground; stipes stout, 8′—12′ long; fronds 3°—5° long, sub-coriaceous, pinnate; the pinnæ 8′—15′ long, 2′—4′ broad, oblique to the rachis, pinnatifid nearly to the midrib; segments spinulose-serrate; veinlets forming a single row of oblong sorus-bearing areolæ next the midvein, besides a few oblique empty areolæ outside the fruiting ones, thence free to the margin. California, Arizona.

§ 2. ANCHISTEA Presl. *Fronds uniform, the veins free between the sori and the margins.*

2. **W. Virginica** (L.) Sm. Stipes stout, 12′—18′ long; fronds oblong-lanceolate, 12′—18′ long, 6′—9′ broad; pinnæ linear-lanceolate, 4′—6′ long, ¾′—1′ broad, cut nearly to the rachis into linear-oblong lobes. (*W. Banisteriana* Michx., *Blechnum*

Carolinianum Walt., *B. Virginicum* L., *Doodia Virginica* Presl.) Canada and Florida westward to Michigan and Arkansas.

§ 3. LORINSERIA Presl. *Fronds dimorphous, veins everywhere forming areolæ.*

3. **W. areolata** (L.) Moore. Sterile frond with slender stipes, 9′—12′ long, 6′—8′ broad, deltoid-ovate, with numerous oblong-lanceolate sinuate pinnæ; rachis broadly winged; fertile frond with an elongate, castaneous stem; pinnæ 3′—4′ long, narrowly linear. (*W. onocleoides* Willd., *W. angustifolia* Sm., *Acrostichum areolatum* L.) Maine to Florida, Michigan, Arkansas.

XVI. ASPLENIUM L. SPLEENWORT.

Sori oblong or linear, oblique, separate; indusium straight or rarely curved, opening toward the midrib when single, sometimes double. Veins free in all our species. Name from Gr. α, without, and σπλήν, spleen. A cosmopolitan genus containing nearly 350 species.

§ 1. EUASPLENIUM. *Veins free, simple or branched; indusium straight or slightly curved, attached to the upper side of a vein.*

* *Fronds simple.*

1. **A. serratum** L. Fronds growing in a crown from a short, stout, erect rootstock, 1½°—2½° long, 2′—4′ broad, simple, spatulate or linear-oblanceolate, the margin crenulate or irregularly but finely serrate, sub-coriaceous; midrib prominent, keeled and often blackish purple beneath; veins closely placed, free, once forked; sori elongate, following the veins of the upper half of the frond from near the midrib half-way to the margin; indusia single, the free edge entire. Florida.

** *Fronds pinnatifid or pinnate below, tapering to a point.*

2. **A. pinnatifidum** Nutt. Stipes tufted, 2′—4′ long; fronds 3′—6′ long, 1′—1½′ broad, lanceolate, pinnatifid, or pinnate below, tapering to a slender prolongation above; lobes roundish-ovate, or the lowest pair acuminate; sori numerous. Pennsylvania to Illinois, Kentucky, and Alabama.

3. **A. ebenoides** R. R. Scott. Fronds 4′—9′ long, broadly lanceolate, pinnatifid, pinnate below; apex prolonged and slender; divisions lanceolate from a broad base, the lower ones

shorter; stipes black and polished, as is the lower part of the midrib, especially beneath. Schuylkill River, above Manayunk, Pennsylvania (*Scott*); Havana, Alabama (*Miss Tutwiler*); Canaan, Connecticut (*Adam*); near Poughkeepsie, New York (*Lown*), Jackson County, Illinois (*Patterson*).

*** *Fronds once pinnate.*

† *Pinnæ* ¼′—¾′ *long, mostly blunt.*

‡ *Rachis chestnut-brown or blackish.*

4. **A. platyneuron** (L.) Oakes. Stipes 3′—6′ long, chestnut-brown, nearly naked; fronds 8′—16′ long, linear-lanceolate; pinnæ 20—40, lanceolate, subfalcate, or the lower oblong, ¼′—1 long, the dilated base auricled on the upper or both sides; sori often 10—12 on each side. (*A. ebeneum* Ait., *Polypodium platyneuron* L.) Florida and Kentucky northward to Canada.

5. **A. parvulum** Mart. & Gale. Fronds tufted, erect, rigid, 4′—10′ long, narrowly linear-lanceolate; stipe and rachis black and shining; pinnæ numerous, oblong, obtuse, entire or crenulate, auricled on the upper side, nearly sessile; middle pinnæ longest, the lower gradually shorter and deflexed; sori short, abundant. (*A. ebeneum* var. *minus*, Hook., *A. resiliens* Kunze.) Virginia, South Carolina, and Florida to Arkansas and New Mexico.

6. **A. trichomanes** L. Stipes densely tufted, purple-brown, shining; fronds 3′—8′ long, ½′ or more broad, linear; pinnæ 15—30 pairs, nearly opposite, roundish-oblong or oval, the two sides unequal, obliquely wedge-truncate at the base, attached by a narrow point, the edge slightly crenate, the midvein forking and evanescent; sori 3—6 on each side of the midrib. (*A. melanocaulon* Willd.) Eastern United States to the Pacific coast.

Var. **incisum** Moore. Fronds larger, often ¾′ or more broad, pinnæ more or less deeply incised. California, Vermont.

7. **A. monanthemum** L. Stipes densely tufted, 3′—6′ long, chestnut-brown; fronds 6′—12′ long, narrow, with 20—40 pinnæ on each side; pinnæ crenate above, abruptly narrowed at base, often auricled, the lower much reduced; texture subcoriaceous; veins flabellate; sori 1—2, linear-oblong, parallel

with lower edge of pinnæ. Huachuca Mountains, Arizona (*Lemmon*).

‡‡ *Rachis green.*

8. **A. viride** Huds. Stipes densely tufted, 2′—4′ long, naked, the lower part chestnut-brown; fronds 2′—6′ long, ½′ broad, with 12—20 pinnæ on each side, which are ovate or rhomboidal in outline, the upper edge narrowed suddenly at the base, the lower obliquely truncate, the outer part deeply crenate; rachis naked; sori copious. Vermont, Canada, and New Brunswick.

9. **A. dentatum** L. Stipes tufted, 2′—6′ long, naked, ebeneous below; fertile fronds 2′—3′ long, 1′ broad, with 6—8 pairs of stalked, oblong-rhomboidal pinnæ, the lower side truncate with a curve, the outer edge irregularly crenate; sterile fronds smaller on shorter stipes; rachis naked; sori copious in parallel rows. Florida, South Carolina.

†† *Pinnæ only* 2—5, *linear-cuneate.*

10. **A. septentrionale** (L.) Hoffm. Stipes dense, tufted, 3′—6′ long, slender, naked, ebeneous toward the base; fronds irregularly forking, consisting of two to five narrowly linear rather rigid segments, which are entire or more frequently cleft at the end into a few long narrow teeth; sori elongate, placed near the margin, usually facing each other in pairs, commonly only two or three to each segment. Ben Moore, New Mexico (*Bigelow*); Middle Mountains, Colorado, Arizona.

††† *Pinnæ numerous, linear or linear-oblong, acute or acuminate.*

11. **A. angustifolium** Michx. Stipes 1° or more long, brownish, slightly scaly below; fronds 1½°—2° long, 4′—6′ broad, lanceolate-oblong, flaccid; pinnæ 20—30 pairs, linear-lanceolate, acuminate, entire or crenulate, those of the fertile frond narrower; texture thinly herbaceous; sori linear, 20—40 each side of the midvein. New England to Kentucky and Wisconsin.

12. **A. firmum** Kunze. Stipes 4′—8′ long, erect, grayish, naked; fronds 6′—12′ long, 3′—4′ broad; pinnæ 12—20 pairs, oblong-lanceolate, the point bluntish, the margin inciso-crenate, the upper one narrowed suddenly at the base, the lower

one obliquely truncate; sori short, falling short of both mid-vein and margin. Florida, Arizona.

**** *Fronds bi—tripinnatifid.*

† *Texture somewhat coriaceous.*

13. **A. ruta-muraria** L. Stipes tufted, 2′—4′ long, naked; fronds ovate-deltoid, 1′—2′ long, bi—tripinnate below, simply pinnate above; the divisions rhombic-wedge-shaped, toothed or incised at the apex; veins flabellate; sori few, elongate, soon confluent. Vermont to Michigan and Kentucky.

14. **A. montanum** Willd. Stipes tufted, 2′—3′ long, naked; fronds 2′—5′ long, ovate-lanceolate, pinnate; pinnæ 3—7 parted below, incised or toothed above; veins obscure; sori short, the basal ones sometimes double. Lantern Hill, Connecticut, and Ulster County, New York, to Georgia, Kentucky, and Arkansas; Cuyahoga Falls, Ohio (*Kirby*).

15. **A. Glenniei** Baker. Stipes densely tufted, ½′—1′ long, castaneous; fronds 3′—4′ long, bipinnate; pinnæ 20—25 pairs, lanceolate, the lower gradually reduced; pinnules 5—6 pairs, toothed or externally sub-entire. Huachuca Mountains, Arizona (*Lemmon*).

16. **A. fontanum** (L.) Bernh. Stipes 1′—3′ long, slightly scaly at base; fronds 3′—6′ long, ½′—1′ wide, tapering both ways from above the middle; pinnæ 10—15 pairs, their segments deeply dentate with spinulose teeth; sori one or two to each segment. Lycoming County, Pa. (*McMinn*), Springfield, Ohio *Spence*).

†† *Texture thinly herbaceous or membranous.*

17. **A. Bradleyi** D. C. Eaton. Stipes tufted, 2′—3′ long, ebeneous, as is also the lower half of rachis; fronds 3′—7′ long, pinnatifid; pinnæ 8—12 pairs, the lowest not reduced, the largest pinnatifid with oblong lobes toothed at the tip; sori short. Ulster County, N. Y., Lancaster, Pa., Kentucky, Tennessee, and Arkansas.

18. **A. rhizophyllum** Kunze, *var.* **myriophyllum** Mett. Stipes tufted, 2′—6′ long; fronds 3′—10′ long, lanceolate, bi—tripinnate; segments entire or 2—3-lobed, bearing a single vein and sorus. Forms with fronds narrowly linear, ¾′—1′ wide, and

widely ascending, 7—8-lobed pinnæ, are var. *Biscaynianum* D. C. Eaton. Florida.

19. **A. cicutarium** Swz. Stipes tufted, 4′—8′ long, greenish, naked; fronds 6′—15′ long, 4′—6′ broad, with 10—15 horizontal pinnæ on each side, the lower ones 2′—3′ long, 1′ broad, cut down to the rachis into linear or oblong segments, which are once or twice cleft at the apex; rachis compressed and often winged; sori principally in two rows. Florida.

§ 2. ATHYRIUM Roth. *Veins free; sori more or less curved, sometimes horseshoe-shaped, often crossing to the outer or lower side of the fruiting veinlet.*

20. **A. thelypteroides** Michx. Stipes long, erect, stramineous; fronds 1°—2° long, 6′—12′ broad, bipinnatifid; pinnæ linear-lanceolate; segments crowded, oblong, minutely toothed; sori 5—6 pairs to each segment, slightly curved, the lower ones often double. New England to Kentucky and Illinois.

21. **A. filix-fœmina** (L.) Bernh. (LADY-FERN.) Stipes tufted, 6′—12′ long, stramineous or brownish; fronds delicate, 1½°—3° long, broadly oblong-ovate, bipinnate; pinnæ 4′—8′ long, lanceolate; pinnules oblong-lanceolate, pointed, more or less pinnately incised or serrate, distinct or confluent on the secondary rachises by a very narrow and inconspicuous margin; sori short; indusium straight or variously curved. Small starved specimens growing in mountainous places form the *var. exile* D. C. Eaton, often fruiting when 3′—6′ high. Narrow forms with the pinnæ obliquely ascending are *var. Michauxii* Mett. (*var. angustum* D. C. Eaton), and other forms equally unimportant, form the remaining *sixty-three varieties* that have been described of this species. (*Aspidium filix-fœmina* Swz., *Nephrodium asplenoides* Michx.) Eastern United States to Utah, Nevada, California, and Arizona.

XVII. SCOLOPENDRIUM Sm. HART'S-TONGUE.

Sori linear, elongate, almost at right angles to the midvein, contiguous by twos, one on the upper side of one veinlet, and the next on the lower side of the next superior veinlet, thus appearing to have a double indusium opening along the middle. Name from Gr. *σκολόπενδρα*, a centipede, alluding to the position of the sori. Includes five species.

1. **S. vulgare** Sm. Stipes 2′—6′ long, fibrillose below; fronds oblong-lanceolate from an auricled heart-shaped base, entire or undulate, 7′—18′ long, 1′—2′ wide, bright green. (*S. officinarum* Swz., *Asplenium scolopendrium* L.) Chittenango Falls and Jamesville, New York; Woodstock, New Brunswick (*Sutton*), Owen Sound, Canada (*Mrs. Roy*), Tennessee.

XVIII. CAMPTOSORUS Link. Walking-leaf.

Sori oblong or linear, irregularly scattered on either side of the reticulate veins of the simple frond, those next the midrib single, the outer ones inclined to approximate in pairs, or to become confluent at their ends, thus forming crooked lines. Name from Gr. *καμπτός*, curved, and *σωρός*, a heap. Includes only two species.

1. **C. rhizophyllus** (L.) Link. Fronds evergreen, tufted, spreading or procumbent, 4′—9′ long, lanceolate from an auricled, heart-shaped or often hastate base, tapering above into a slender prolongation which often roots at the apex. Var. *intermedius* Arthur is an interesting form, differing mainly from the typical forms in having the base acute, without proper auricles and with a single fibro-vascular bundle in the stipe. (*Antigramma rhizophylla* J. Sm., *Scolopendrium rhizophyllum* Hook., *Asplenium rhizophyllum* L.) New England to Wisconsin and southward; the variety in Iowa.

XIX. PHEGOPTERIS Fee. Beech-fern.

Sori small, round, naked, borne on the back of the veins below the apex. Stipe continuous with the rootstock. Veins free or reticulate. Name from Gr. *φηγός*, a beech-tree, and *πτερίς*, a fern. Includes 95 species.

§ 1. Euphegopteris. *Veins free.*

* *Fronds triangular, bipinnatifid; pinnæ sessile, adnate to a winged rachis.*

1. **P. connectilis** (Michx.) Watt. Stipes 6′—9′ long; fronds longer than broad, 4′—9′ long, 4′—6′ broad, hairy on the veins especially beneath; pinnæ linear-lanceolate, the lowest pair deflexed and standing forward; segments oblong, obtuse, entire, the basal ones decurrent and adnate to the main rachis; sori near margin. (*P. polypodioides* Fee, *Polypodium phegopteris* L., *P. connectile* Michx.) New England to Virginia and westward.

2. **P. hexagonoptera** (Michx.) Fee. Stipes stramineous, naked; fronds as broad as long or nearly so, 7′—12′ long, slightly pubescent, and often finely glandular beneath; upper pinnæ oblong, obtuse, toothed or entire, the very large, lowest pinnæ elongate and pinnately lobed; sori near the margin or some between the sinus and the midrib. (*Polypodium hexagonopterum* Michx.) Canada to Illinois, Kentucky, and Florida.

** *Fronds oblong-lanceolate, tripinnatifid; rachis wingless.*

3. **P. alpestris** (Hoppe) Mett. Rootstock short, erect or oblique; stipes 4′—10′ long, with a few brown spreading scales near the base; fronds 1°—2° long, pinnæ deltoid-lanceolate, the lower ones distant and decreasing moderately; pinnules oblong-lanceolate, incised and toothed; sori small, rounded, submarginal. (*Polypodium alpestre* Hoppe, *Aspidium alpestre* Swz.) California and northward; Idaho (*Sandberg*).

*** *Fronds ternate, the three divisions petioled; rachis wingless.*

4. **P. dryopteris** (L.) Fee. (OAK-FERN.) Rootstock slender, creeping; fronds broadly triangular, 4′—8′ wide; the three primary divisions 1—2-pinnate; segments oblong, obtuse, entire or toothed; sori near the margin. (*Polypodium dryopteris* L., *Nephrodium dryopteris* Michx.) Northeastern United States to Virginia, and westward to Oregon and Alaska.

Var. **Robertianum** (Hoffm.) Dav. Stipes 6′—10′ long, stramineous, glandular; fronds 6′—8′ long, 5′—7′ wide, deltoid-ovate in outline, bipinnate, lowest pair of pinnæ far the largest, pinnatifid or again pinnate; upper pinnæ smaller, pinnatifid, lobed, or entire; sori copious, forming submarginal rows around the segments. (*P. calcarea* Fee.) Minnesota (*Cathcart*), Decorah, Iowa (*Holway*), Northeast Territory (*Macoun*), Idaho.

§ 2. GONIOPTERIS Presl. *Veins pinnate, the lower veinlets of contiguous groups uniting.*

5. **P. tetragona** (Swz.) Fee. Rootstock creeping; stipes 6′—18′ long, naked or slightly villose; fronds 1°—2° long, 6′—12′ broad; pinnæ numerous, spreading 3′—6′ long, the lowest narrowed at the base and sometimes stalked, deeply pinnatifid; texture thinly herbaceous; rachis and under surface finely pubescent; sori in rows near the midrib. Marion County, Florida (*Reynolds*).

6. **P. reptans** (Swz.) Eaton. Rootstock short, creeping; stipes 3′—10′ long, clustered, gray-stamineous, slender, naked; fronds 4′—12′ long, membranous, softly hairy with branched or stellate hairs, oblong-lanceolate, pinnate with nearly or quite sessile, oblong, crenately pinnatifid pinnæ, the apex pinnatifid, often elongate and rooting; veins pinnate, simple, the basal veinlets often anastomosing; sori on the middle of the veinlets, rather small, sometimes with a minute rudimentary indusium. (*Polypodium reptans* Swz., *Aspidium reptans* Mett.) On calcareous rocks, on left bank of Withlacoochee River, 15 miles N.E. from Brooksville, Florida (*J. Donnell Smith*).

XX. DRYOPTERIS Adans. Shield-fern.

Sori round, borne on the back or rarely at the apex of the veins. Indusium flat or flattish, orbicular and peltate at the centre, or cordato-reniform and fixed either centrally or at the sinus. Stipe continuous with the rootstock. Name from Gr. δρῦς, oak, and πτερίς, a fern. (*Aspidium* Swz. and former editions.) A cosmopolitan genus containing 350 species.

§ 1. Aspidium. *Veins anastomosing copiously.*

1. **D. trifoliata** (L.) Ktze. Stipes tufted, 1° or more long, brownish, scaly at base; fronds 12′—18′ long, 6′—12′ broad, with a large ovate-acuminate terminal pinna narrowed or forked at the base, and one or two lateral ones on each side, the lowest mostly forked; primary veins distinct to the margin; areolæ fine, copious, with free included veinlets; sori in rows near the main veins; indusia orbicular, peltate. Florida, Western Texas.

§ 2. Cyrtomium Presl. *Indusium peltate; fronds simply pinnate with broad pinnæ; veinlets usually uniting slightly near the margin.*

2. **D. juglandifolia** (HBK) Ktze. Stipes tufted, clothed below with large scales; fronds 6′—2° long, coriaceous; pinnæ 2—12 pairs, short-stalked, ovate-oblong or broadly lanceolate, the terminal one distinct, and in small fronds the largest, appressed-serrulate, smooth on both surfaces; veins pinnate, the veinlets few, free or uniting near the margin; sori scattered in several irregular rows. Western Texas, Arizona.

§ 3. Polystichum Roth. *Indusium orbicular and entire,*

peltate, fixed by the depressed centre; pinnæ and pinnules usually auricled on the upper side at base, mucronately serrate; veins free.

* *Fronds simply pinnate.*

† *Fronds long-stalked, lanceolate.*

3. **D. acrostichoides** (Michx.) Ktze. (CHRISTMAS-FERN.) Stipes 6′—8′ long, clothed below with pale-brown lanceolate scales; fronds ½°—2° high, 3′—5′ broad; pinnæ linear-lanceolate, somewhat falcate, half-halberd-shaped at the base, serrulate with appressed bristly teeth; the fertile ones contracted and smaller, bearing contiguous sori near the middle, soon covering the entire surface. A form with cut-lobed, often strongly falcate pinnæ, set obliquely to the rachis, and with the tips of nearly all bearing sori, is the *var. incisum* Gray. (*Nephrodium acrostichoides* Michx.) New England to Florida, Mississippi, and northward.

4. **D. munita** (Kaulf.) Ktze. Stipes 4′—12′ long, chaffy, the rachis with brown scales; fronds growing in a crown, 1°—4° long, tapering slightly toward the base; pinnæ numerous, linear-acuminate, 3′—4′ long, very sharply and often doubly serrate, with appressed needle-like points; sori numerous, forming a single row each side of the midrib half-way to the margin. California and northward.

†† *Fronds scarcely stalked, linear-lanceolate.*

5. **D. lonchitis** (L.) Ktze. (HOLLY-FERN.) Fronds 9′—20′ long, rigid; pinnæ 1′ or more long, broadly lanceolate-falcate or the lowest triangular, strongly auricled on the upper side, the lower obliquely truncate, densely spinulose-toothed; sori contiguous and near the margin. Canada and Wisconsin to Utah (*Jones*), Castle Lake, Siskiyou County, California (*Pringle*), Mt. Peddo, Washington (*Suksdorf*), and northward.

** *Fronds bipinnate or nearly so.*

6. **D. mohrioides** (Bory) Ktze. Stipes 2′—6′ long, more or less densely clothed with lanceolate dark-brown scales; fronds 6′—12′ long, 2′—3′ broad, with numerous dense, often imbricated, lanceolate pinnæ, which are cut below into slightly toothed oblong rhomboidal pinnules; teeth blunt or mucronate; texture coriaceous; both surfaces naked; rachis stout

compressed, scaly; veins close, immersed; sori copious. California.

7. **D. aculeata** (L.) Ktze. Rootstock stout; stipes variable in length, very chaffy with large and small scales intermixed as in the rachis; fronds 1°—2° long, growing in a crown, oblong-lanceolate, pinnate; pinnæ closely placed, lanceolate from a broad base, mostly curved upwards, incisely pinnatifid or again pinnate; segments or pinnules of variable shape, oval-rhomboidal, or unequally triangular-ovate and auriculate on the upper side of the slightly stalked base, the teeth aculeate in various degrees; under surface more or less chaffy-fibrillose; sori in two rows, on the segments nearer the midvein than the edge. California, Mt. Peddo, Washington (*Suksdorf*).

Var. **Californica** (Eat.) Unde. Fronds elongate, narrow, tapering slightly at the base; pinnæ but slightly incised above the middle, more and more deeply cleft toward the rachis, the lower superior segment largest, but scarcely distinct as a pinnule, and not at all auricled. (*A. Californicum* D. C. Eaton.) California.

Var. **angularis** (Willd.) Unde. Fronds lanceolate, scarcely or not at all narrowed at the base, fully bipinnate; pinnules distinctly short-stalked, mostly auricled and slightly incised; the basal one largest and again pinnatifid; under surface chaffy-fibrillose. (*A. angulare* Willd.) California.

Var. **Braunii** (Spenner) Koch. Fronds lanceolate; pinnæ numerous, oblong-lanceolate, the lower gradually reduced in size and obtuse; pinnules ovate or oblong, truncate and almost rectangular at the base, sharply toothed, beset with long soft hairs as well as chaffy ones. (*A. Braunii* Spenner.) Maine to New York and northward.

§ 4. NEPHRODIUM Rich. *Indusium cordato-reniform or orbicular with a narrow sinus; veins free.*

* *Texture thin-membranous, veins simple or once forked, fronds bipinnatifid.*

† *Lowest pinnæ gradually reduced to mere lobes.*

8. **D. Noveboracensis** (L.) Gray. Rootstock creeping; fronds 1°—2° long, 4′—6′ broad, lanceolate, tapering both ways from the middle; pinnæ lanceolate, the two or more lowest

pairs gradually shorter and deflexed, those of the barren frond broader; segments flat, oblong, basal ones often enlarged; veins simple or forked in basal lobes; sori distinct, near the margin; indusium minute, the margin glanduliferous. (*A. thelypteroides* Swz., *Polypodium Noveboracense* L., *Nephrodium Noveboracense* Desv., *Lastrea Noveboracensis* J. Sm.) North Carolina to Arkansas and northward.

9. **D. contermina** (Desv.) Ktze., *var.* **strigosa** (Fee) Unde. Rootstock stout, erect, often extending a foot above the ground, bearing a crown of fronds; stipes very stout, narrowly wing-margined at the base; fronds 1°—4° long, lanceolate in outline, caudate-acuminate, much narrowed at the base, somewhat rigid, pinnate; pinnæ sessile, narrowly lanceolate from a broader base, acuminate, deeply pinnatifid into oblong, obliquely sub-falcate, obtuse segments; under-surface copiously dotted with resinous globules; veins free, simple; sori near the margin; indusium reniform, minute, glandular, somewhat pilose, evanescent. (*A. strigosum* Fee, *Nephrodium conterminum* Desv. in part.) Florida.

10. **D. Nevadensis** (Eat.) Unde. Rootstock creeping, densely covered with the persistent bases of former stalks; fronds in a crown, 1½°—3° long, lanceolate; pinnæ linear-lanceolate from a broad base, deeply pinnatifid, the lower pairs distant and gradually reduced to mere auricles; segments crowded, oblong, slightly hairy on the veins beneath, and sprinkled with minute resinous particles; veins about seven pairs to a lobe; sori close to the margin; indusium minute, furnished with a few dark-colored marginal glands, and bearing several straight jointed hairs on the upper surface. California.

11. **D. Montana** (Vogl.) Ktze. Rootstock erect or decumbent, scaly; stipes short, tufted, scaly below; fronds 1½°—2° long, firm, membranous, broadly lanceolate, gradually tapering and attenuated below, glandular; pinnæ 2′—3′ long, sessile from a broad base, lanceolate-acuminate, deeply pinnatifid, gradually shorter to the lowest, which are more distant, deltoid, and less than 1′ long; segments flat, nearly entire, oblong; sori quite marginal; indusia delicate, membranous, more or less toothed at the margin. (*Nephrodium oreopteris* Desv., *N. mon-*

tanum Baker.) Unalaska, Mount Dawson, British Columbia (*Macoun*).

†† *Lower pinnæ little smaller than those above.*

12. **D. thelypteris** (L.) Gray. (MARSH-FERN.) Rootstock slender; fronds 1°—2° long, 4′—6′ broad, lanceolate, pinnæ mostly horizontal, linear-lanceolate; segments oblong, entire, obtuse or appearing acute in fruit from the strongly revolute margins; veins mostly forked, bearing the sori near their middle; indusia minute, smooth, and naked. (*Polypodium thelypteris* L., *Nephrodium thelypteris* Desv., *Lastrea thelypteris* J. Sm.) Northern United States to Florida.

13. **D. patens** (Swz.) Ktze. Rootstock stout, bearing several fronds at the growing end; fronds 2°—3° long, 4′—10′ broad, ovate-oblong, softly pubescent beneath; pinnæ closely placed, linear-acuminate, lowest pair somewhat deflexed, all cut three fourths of the way to the midrib; segments numerous, acutish, basal ones longest; veinlets evident, lowest ones of adjoining segments often uniting; sori near the margin; indusia very pubescent. (*A. molle* Kunze.) Florida to California.

** *Texture firmer or sub-coriaceous, veins forking freely.*

† *Fronds pinnate; pinnæ cut into spreading triangular lobes; sori confluent.*

14. **D. unita** (L.) Ktze., *var.* **glabra** (Mett.) Unde. Stipes 1½° long, brownish, naked; fronds 1½° or more long, 5′—8′ broad; pinnæ narrow, cut from one third to half-way down into sharp, pointed lobes; lower pinnæ not reduced; veins pinnate in the broad lobes with 6—8 veinlets on each side, the lower ones of contiguous groups united; sori near the ends of the veins principally in the lobes. Florida.

†† *Fronds bipinnatifid or bipinnate; indusia rather large; segments not spinulose.*

‡ *Fronds small, narrowly lanceolate.*

15. **D. fragrans** (L.) Schott. Fronds 4′—12′ high, glandular-aromatic; pinnæ linear-oblong, pinnately parted; segments toothed or nearly entire, nearly covered beneath with the very large thin imbricate indusia, which are orbicular with a narrow sinus, the margin ragged and sparingly glanduliferous. (*Ne-*

phrodium fragrans Rich.) New England, New York to Wisconsin, and northward.

‡‡ *Fronds larger, mostly 2°—4° high.*

A. *Fronds bipinnatifid or nearly twice pinnate; indusia large, thinnish and flat,*

16. **D. Floridana** (Hook.) Ktze. Stipes 6′—10′ long, sparingly clothed with ovate scales; fronds lanceolate, 18′—20′ long, 5′—8′ broad; fertile pinnæ confined to the upper half of the frond, narrowly lanceolate, cut down to the narrowly winged secondary rachises into oblong, distinct pinnules; the sterile pinnæ broader, shorter, and sub-deltoid below, less deeply cut. (*Aspidium Floridanum* D. C. Eaton, *Nephrodium Floridanum* Hook.) Florida.

17. **D. cristata** (L.) Gray. Fronds linear or lanceolate in outline, 1°—2° long; pinnæ short, 2′—3′ long, triangular-oblong or the lowest nearly triangular, deeply pinnatifid; segments 6—10 pairs, finely serrate or cut-toothed; sori as near the midvein as the margin; indusia smooth, naked. (*A. Lancastriense* Spreng., *Nephrodium cristatum* Michx., *Lastrea cristata* Presl.) Canada to Arkansas.

Var. **Clintoniana** (Eat.) Unde. Fronds much larger, 2½°—4° long; pinnæ oblong-lanceolate, broadest at base, 4′—6′ long, 1′—2′ broad, deeply pinnatifid; segments 8—16 pairs, crowded or distant, linear-oblong, obscurely serrate; veins pinnately forking, bearing the sori near the midvein. New England, New York, and westward.

18. **D. Goldieana** (Hook.) Gray. Fronds broad, 2°—4° long; pinnæ 6′—9′ long, broadest in the middle, pinnately parted; the segments about 20 pairs, oblong-linear, sub-falcate, serrate with appressed teeth; veins bearing the sori very near the midvein; indusia very large, orbicular with a narrow sinus. (*Nephrodium Goldieanum* Hook., *Lastrea Goldieana* J. Sm.) Canada to Kentucky.

B. *Fronds mostly bipinnate; indusia convex, without marginal glands.*

19. **D. filix-mas** (L.) Schott. (MALE-FERN.) Rootstock stout; fronds in a crown, 1°—3° high, broadly oblong lanceolate, slightly narrowed toward the base, bipinnatifid or bipin-

nate; pinnules oblong, smooth, polished beneath, the larger ones pinnately incised; sori large, near the midvein, commonly on the lower half or two thirds of the segment; indusia firm, smooth; rachis more or less chaffy. (*Nephrodium filix-mas* Rich., *Lastrea filix-mas* Presl.) Canada to Colorado, Arizona, California, and Oregon.

20. **D. marginalis** (L.) Gray. Fronds nearly coriaceous in texture, 6′—2° long, ovate-oblong; pinnæ lanceolate, broadest just above the base; pinnules oblong or oblong-falcate, entire or crenately toothed; sori close to the margin. (*Polypodium marginale* L., *Nephrodium marginale* Michx., *Lastrea marginalis* J. Sm.) Northern United States and Canada.

††† *Fronds bipinnate or tripinnatifid; segments spinulose toothed.*

21. **D. rigida** (Hoffm.) Unde., *var.* **arguta** (Kaulf.) Unde. Rootstock short, stout; fronds in a crown on chaffy stalks, half-evergreen, smooth above, paler and more or less glandular beneath, 1°—3° high, ovate-lanceolate or triangular-lanceolate, bipinnate; pinnæ broadly oblong-lanceolate, the lowest ones broadest, scarcely shorter than the middle ones; pinnules oblong, incised or doubly serrate with spinulose teeth; indusia firm, convex, the edge bearing short-stalked glands. (*A. argutum* Kaulf.) California, Oregon, British Columbia.

22. **D. spinulosa** (L.) Ktze. Stipes with a few, pale, deciduous scales; fronds ovate-lanceolate, bipinnate, the pinnæ oblique to the rachis, elongate-triangular, the lower pairs broadly triangular; pinnules oblique to the midrib, connected by a very narrow wing, oblong, incised, or pinnatifid with lobes spinulose toothed; indusia smooth without marginal glands. (*Nephrodium spinulosum* Desv., *Lastrea spinulosa* Presl.) Canada and Northern United States.

Var. **intermedia** (Willd.) Unde. Scales of the stipes brown with a darker centre; fronds oblong-ovate, bi—tripinnate; pinnæ spreading, oblong-lanceolate, the lowest unequally triangular-ovate; pinnules crowded, pinnately divided; margin of indusium denticulate and beset with stalked glands. (*A. intermedium* Willd., *A. Americanum* Dav.) Canada to Tennessee.

Var. **dilatata** (Hoffm.) Unde. Scales of stipes large,

brown with a darker centre; fronds broadly ovate or triangular-ovate, oftenest tripinnate; pinnules lance-oblong, the lowest often much elongated; indusia smooth and naked. (*A. dilatatum* Swz., *A. campylopterum* Kunze., *Nephrodium dilatatum* Desv., *Lastrea dilatata* J. Sm.) A dwarf form is *var. dumetorum.* Canada and New England to Oregon.

23. **D. Boottii** (Tuck.) Unde. Scales of stipes pale brown; fronds elongate oblong or elongate lanceolate in outline; pinnules broadly oblong, very obtuse, the lower pinnatifid, the upper and smaller merely serrate; indusia minutely glandular. (*A. spinulosum*, var. *Boottii* Gray.) New England, New York, and northward.

24. **D. patula** (Swz.) Unde. Stipes 8′—12′ long, stramineous, scaly at base; fronds pale green, 1°—2° long, 6′—12′ broad, ovate-lanceolate; pinnæ lanceolate or the lower subdeltoid; rachis and both surfaces naked; sori in rows midway between edge and midrib; indusium conspicuous, naked. (*Nephrodium patulum* Baker, *N. Mexicanum* Hook. Distributed by Lemmon as *A. Karwinskyanum.*) Huachuca Mountains, Arizona (Lemmon).

XXI. NEPHROLEPIS Schott.

Sori round, arising from the apex of the upper branch of a vein, usually near the margin. Indusia reniform or roundish. Veins all free, the fronds simply pinnate, the pinnæ articulated at the base, and bearing white cretaceous dots on the upper surface. Name from Gr. *νεφρώς*, a kidney, and *λεπίς*, a scale. A tropical and sub-tropical genus containing seven species.

1. **N. exaltata** (L.) Schott. Stipes 4′—6′ long, naked or slightly scaly; fronds 1°—6° long, 3′—6′ broad; pinnæ close, lanceolate, the edge entire or slightly crenate, the upper side auricled at the base, the lower rounded; rachis nearly naked; sori sub-marginal; indusia firm, distinctly reniform. Florida; frequent in cultivation.

2. **N. acuta** (Swz.) Presl. Stipes 4′—8′ long, naked or slightly scaly; fronds 2°—4° long, 8′—12′ broad; pinnæ 4′—8′ long, ½′—1′ broad, acute, entire or slightly crenate, the upper side auricled, the lower rounded at base; rachis and both sides nearly naked; sori submarginal; indusia suborbicular, subpel-

tate. South bank of Miami River, Florida. March, 1887 (*Holden*).

XXII. CYSTOPTERIS Bernh. Bladder-fern.

Sori roundish, borne on the back of the veins. Indusium delicate, hood-like, or arched, attached by a broad base on the inner side partly under the sorus, early opening, free at the other side, and thrown back or withering away. Veins free. Name from Gr. κύστις, a bladder, and πτερίς, a fern, alluding to the inflated indusia. Found in the temperate zones of both hemispheres; contains five species.

** Fronds ovate-lanceolate, bi—tripinnate.*

1. **C. bulbifera** (L.) Bernh. Stipes 4′–6′ long; fronds lanceolate, elongate, 1°—2° long, bi–tripinnatifid, pinnæ lanceolate-oblong; pinnules crowded, toothed or pinnatifid; rachis wingless, often bearing bulblets underneath; indusia short, truncate on the free side. (*Aspidium bulbiferum* Swz., *Nephrodium bulbiferum* Michx.) New England to Virginia and North Carolina.

2. **C. fragilis** (L.) Bernh. Fronds oblong-lanceolate, 4′–8′ long, 1′—2½′ broad, bi tripinnate; pinnæ and pinnules lanceolate or ovate in outline, decurrent along the margined or winged rachis; indusia tapering or acute at the free end. Narrower, less divided specimens, barely bipinnate with obtuse and bluntly toothed pinnules form the *var. dentata* Hook. Like many other so-called varieties it passes insensibly into the typical form. (*Aspidium tenue* Swz.) New England to Arizona, California, and northward.

*** Fronds deltoid-ovate, tri—quadripinnate.*

3. **C. montana** (Lam.) Bernh. Rootstock slender, creeping; stipes 6′–9′ long, slender; fronds about 6′ each way; lowest pinnæ deltoid-lanceolate, much larger than those above, their inferior pinnules 1′—1½′ long; segments cut to the rachis into oblong lobes, deeply and sharply toothed; sori numerous. Colorado (*Brandegee*), north shore of Lake Superior, Labrador (*Datler*), Mt. Albert, Gaspe, Quebec, and northward to Alaska.

XXIII. ONOCLEA L.

Sori round, borne on the back of the veins of the contracted fertile frond, and quite concealed by their revolute margins. Indusium very thin membranous, hemispheric or hood-like, fixed at the inferior side of the sorus. Fronds conspicuously dimorphous. Name from Gr. *ονος*, a vessel, and *κλειειν*, to close, alluding to the fertile fronds. A cold temperate genus containing three species.

§ 1. EUONOCLEA. *Veins of sterile frond copiously anastomosing.*

1. **O. sensibilis** L. (SENSITIVE-FERN.) Fertile fronds bipinnate, much contracted; pinnules short, usually rolled up and converted into berry-shaped closed involucres, and forming a one-sided panicle; sterile fronds broadly triangular, deeply pinnatifid into lanceolate-oblong pinnæ, which are entire, undulate, or the lowest pair sinuate pinnatifid; veins copiously anastomosing. In *var. obtusilobata* Torr. the sterile fronds are again pinnatifid, more or less contracted and revolute, and bear a few sori. New England to Florida and Kansas.

§ 2. STRUTHIOPTERIS Willd. *Veins all free.*

2. **O. struthiopteris** (L.) Hoffm. (OSTRICH-FERN.) Fertile fronds 1°—1½° long, simply pinnate with necklace-shaped pinnæ formed of the strongly revolute margins; sterile fronds 2°—6° long, growing in a crown, broadly lanceolate, bipinnatifid, the lowest pinnæ gradually much shorter; veins pinnate, free and simple; sori crowded and confluent. Sterile fronds are sometimes partially contracted and bear sori analogous to *var. obtusilobata* above. (*O. Germanica* Willd., *O. nodulosa* Michx., *Struthiopteris Pennsylvanica* Willd., *S. Germanica* Willd., *Osmunda struthiopteris* L.) New England to Illinois.

XXIV. WOODSIA R. Br.

Sori round, borne on the back of simply forked free veins. Indusium inferior, thin and often evanescent, either small and open, or early bursting at the top into irregular pieces or lobes. Named for *Joseph Woods*, an English botanist. A genus of high temperate or boreal latitudes including 15 species.

§ 1. EUWOODSIA. *Indusium minute or evanescent, open and*

flat from an early stage, concealed under the sorus, its margin cleft into slender hairs or cilia.

* *Stipes obscurely jointed near the base; cilia of the indusium long, inflexed over the sporangia.*

† *Fronds thickly clothed underneath with rusty bristle-like chaff.*

1. **W. Ilvensis** (L.). R. Br. Fronds broadly lanceolate, smoothish above, pinnate; pinnæ crowded, sessile, pinnately-parted, the crowded segments oblong, obscurely crenate; sori near the margin, somewhat confluent when old. (*W. rufidula* Beck., *Acrostichum Ilvense* L., *Polypodium Ilvense* Swz., *Nephrodium rufidulum* Michx., *Aspidium rufidulum* Willd.) Virginia to Kentucky, westward and northward.

†† *Fronds glabrous or nearly so.*

2. **W. alpina** (Bolt.) S. F. Gray. Stipes and rachis often slightly hairy; fronds linear-lanceolate, pinnate; pinnæ cordate-ovate, pinnatifid with few (5—7) broadly obovate entire lobes. Vermont, New York, and northwestward. (*W. hyperborea* R. Br.)

3. **W. glabella** R. Br. Smooth and naked throughout; fronds linear, tapering slightly below, 2′—5′ high, pinnate; pinnæ deltoid or ovate, the lower rather remote, cut into 3—7 rounded or subcuneate entire lobes. Vermont, New York, and northward.

** *Stipes not jointed; cilia of the indusium very short, hidden by the sporangia.*

4. **W. scopulina** D. C. Eaton. Rootstock short, creeping, very chaffy; stipes 2′—4′ long, puberulent like the rachis and under surface of the frond with minute flattened hairs and stalked glands; fronds lanceolate, 4′—8′ long, pinnate; pinnæ numerous, oblong-ovate, pinnatifid with 10—16 short ovate or oblong toothed divisions; indusia very delicate, deeply cleft into laciniæ which terminate in short hairs. Colorado, Arizona, California, Oregon, and northward.

5. **W. Oregana** D. C. Eaton. Stipes and fronds smooth; fertile fronds taller than the sterile ones; pinnæ triangular-oblong, pinnatifid; segments oblong or ovate, toothed or crenate; teeth often reflexed and covering the submarginal sori; indusia

very minute, divided almost to the centre into a few beaded hairs. Arizona, Utah, Colorado, Oregon, and northward.

6. **W. Mexicana** Fee. Stipes 2′—3′ long, smoothish or with a few scattered scales; fronds 3′—9′ long, lanceolate; pinnæ sub-opposite, triangular-lanceolate, pinnately divided into finely-toothed segments, the teeth in young fronds ending in delicate, semi-transparent, ciliated tips; sori near the margin, broad, confluent; receptacles dot-like, scales of indusium four, laciniate, narrow, dividing at the end into articulated hairs; sporangia nearly sessile. Arizona, New Mexico.

§ 2. HYPOPELTIS Torr. *Indusium conspicuous, at first enclosing the sporangium, but early opening at the top and splitting into several spreading jagged lobes.*

7. **W. obtusa** (Spreng.) Torr. Stipes 3′—6′ long; fronds broadly lanceolate, minutely glandular-hairy, 6′—12′ high, nearly bipinnate; pinnæ rather remote, triangular-ovate or oblong, pinnately parted; segments oblong, obtuse, crenately toothed, the lower ones pinnatifid; veins forked. (*W. Perriniana* H. & G., *Aspidium obtusum* Willd., *Cheilanthes crenata* Kunze, *Hypopeltis obtusa* Torr.) Smaller and more glandular forms are *var. glandulosa* Eaton (*W. Plummeræ* Lemmon). New England to Kentucky, Kansas, and Arizona.

XXV. DICKSONIA L'Her.

Sori small, globular, marginal or intra-marginal. Sporangia borne in an elevated, globular receptacle, enclosed in a membranous, cup-shaped indusium, which is open at the top, and on the outer side partly adherent to a reflexed toothlet of the frond. Named for *James Dickson*, an English botanist, 1738–1822. Includes about 50 species, more than half of which are arborescent.

§ SITOLOBIUM J. Sm.

1. **D. punctilobula** (Michx.) Gray. Rootstock slender, creeping, naked; stipes stout, chaffless; fronds 1°—2½° long, 5′—9′ broad, ovate-lanceolate and pointed, usually tripinnatifid; pinnæ lanceolate, pointed; pinnules cut into oblong and obtuse cut-toothed lobes; rachis and under surface minutely glandular and hairy; sori minute, each on a recurved toothlet, usually one at the upper margin of each lobe. (*D. punctiloba*

Hook., *D. pilosiuscula* Willd. *Nephrodium punctilobulum* Michx., *Aspidium punctilobulum* Torr.) Canada to Tennessee.

XXVI. TRICHOMANES Sm. Filmy-fern.

Sori marginal, terminating a vein, more or less sunken in the frond. Sporangia sessile on the lower part of a cylindrical, filiform, often elongated receptacle. Indusia tubular or funnel-shaped, entire or two-lipped at the mouth. Fronds delicate, pellucid. Name from Gr. *τριχομανες*, the name of some fern, from *τρίχ*, hair, and *μαίνομαι*, producing frenzy, alluding to some supposed property. A tropical and temperate genus containing nearly 100 species.

§ Eutrichomanes.

1. **T. Petersii** Gray. Stipes 1″—2″ long; fronds 3″—10″ long, 1″—2″ broad, oblong-lanceolate or obovate, entire or variously pinnatifid, the younger ones with a few black hairs along the margins; indusium solitary, terminal, funnel-shaped, the mouth expanded and slightly two-lipped, the receptacle included. Winston County, Alabama (*Peters*).

2. **T. radicans** Swz. Rootstock wiry, tomentose; stipes ascending, 1′—3′ long, naked or nearly so, usually broadly winged; fronds 2′—8′ long, 1′—1½′ wide, lanceolate or ovate-lanceolate, bipinnatifid; pinnæ ovate, obtuse, the upper side of the base parallel and appressed to the winged rachis, the lower side cuneate; divisions toothed or divided into linear lobes; indusia terminal on short lobes, tubular or funnel-shaped, the mouth slightly two-lipped; receptacle exserted little or very much. (*T. speciosum* Willd.) Alabama, Tennessee, Kentucky.

XXVII. LYGODIUM Swz. Climbing-fern.

Sporangia ovoid, solitary or occasionally in pairs, in the axils of large imbricated scale-like indusia, which are fixed by their broad bases to short oblique veinlets. Fronds scandent, twining, bearing stalked and variously lobed divisions in pairs. Veins mostly free. Name from Gr. *λυγώδης*, flexible, alluding to the scandent stems. Includes 16 species.

§ Eulygodium.

1. **L. palmatum** (Bernh.) Swz. Stipes slender, twining; fronds 1°—3° long, the short alternate branches or peti-

oles 2-forked, each fork bearing a round-cordate palmately 4—7 lobed pinnule; fertile pinnules above, contracted, several times forked, forming a terminal panicle; surfaces naked; texture thinly herbaceous. (*Hydroglossum palmatum* Willd.) Massachusetts and New York to Kentucky and Florida.

XXVIII. ANEIMIA Swz.

Sporangia ovate, sessile, placed in two rows on the back of the very narrow branchlets of the two long-stalked, panicled, lower branches of a pinnately divided frond, the fertile branches in a few species entirely distinct from the sterile frond. Veins free or anastomosing. Name from Gr. *αναιμια*, bloodless. A small genus chiefly from tropical America, containing 27 species.

§ EUANEIMIA.

1. **A. adiantifolia** (L.) Swz. Rootstock creeping; stipes 1½° long, firm, naked; fronds sparingly pubescent, the two lower branches elongate, pinnately decompound, fertile; sterile portion deltoid-ovate, bi—tripinnate; ultimate segments obovate or cuneate, entire or lobed, striate above with numerous flabellate veins. Florida.

2. **A. Mexicana** Klotzsch. Rootstock creeping, covered with narrow blackish chaff; stipes slender, scattered, 6′—12′ long; the two lower branches of the frond fertile, long-stalked, glandular, bipinnate with densely clustered fructification; the rest of the frond like the sterile ones, deltoid-ovate, simply pinnate; pinnæ about six pairs and a rather large terminal one, short-stalked, ovate-lanceolate, subcoriaceous, smooth and somewhat glossy; midrib distinct, veins free, oblique, parallel, closely placed, once or twice forked. Western Texas.

XXIX. SCHIZÆA Sm.

Sporangia large, ovoid, striate rayed at the apex, naked, vertically sessile in a double row along the single vein of the narrow divisions of the fertile appendages to the slender and simply linear, fan-shaped, or dichotomously many-cleft fronds. Name from Gr. *σχιζειν*, to split, alluding to the forked sterile fronds of foreign species. Includes 16 species.

§ EUSCHIZÆA.

1. **S. pusilla** Pursh. Sterile fronds linear, very slender, flattened and tortuous; fertile ones equally slender, 3′—4′ high,

and bearing at top the fertile appendage consisting of about five pairs of crowded pinnæ, forming a distichous spike. New Jersey; Grand Lake, Nova Scotia (*Miss Knight*); Newfoundland (*De la Pylaie*).

XXX. OSMUNDA L. Flowering-fern.

Fertile fronds or fertile portions very much contracted, bearing short-pedicelled, naked sporangia on the margin of the rachis-like divisions. Sporangia large, globular, opening by a longitudinal cleft into two halves, bearing near the apex a few parallel striæ, the rudiment of a transverse ring. Spores green. Named for *Osmunder*, a Saxon name for the divinity Thor. A genus containing six species mostly north temperate.

* *Fronds bipinnate, fertile at the apex.*

1. **O. regalis** L. Stipes tufted, 1°—1½° long, erect, naked; fronds 2°—4° long, 1° or more broad; sterile pinnæ 6′—12′ long, 2—4′ broad; pinnules oblong-ovate to lance-oblong, sessile or slightly stalked; the fertile pinnules cylindrical, panicled; texture subcoriaceous; rachis and both sides naked. (*O. spectabilis* Willd., *O. glaucescens* Link.) Canada to Florida and Mississippi.

** *Sterile fronds bipinnatifid.*

2. **O. Claytoniana** L. Stipes tufted, 1° or more long, clothed with loose woolly tomentum when young, naked when mature; fronds 1°—2° long, 8′—12′ broad; pinnæ oblong-lanceolate with oblong, obtuse divisions; 2—5 pairs of central pinnæ fertile fertile pinnules dense, cylindrical; texture herbaceous. (*O. interrupta* Michx.) Canada to Kentucky, and northward.

3. **O. cinnamomea** L. (Cinnamon-fern.) Stipes densely tufted, 1° or more long, the sterile and fertile fronds distinct, clothed when young with ferruginous tomentum; sterile fronds smooth when mature, the pinnæ bearing a tuft of tomentum at the base beneath, lanceolate, cut into broadly oblong, obtuse divisions; fertile fronds contracted, bipinnate, with cinnamon-colored sporangia. In *var. frondosa* Gray, some of the fronds are sterile below, and sparsely fertile at the summit. (*O. Claytoniana* Conrad.) New England and Wisconsin to Florida.

ORDER II. MARSILIACEÆ R. Br.

Perennial plants rooted in mud, with a slender creeping rootstock and either filiform or 4-parted, long-petioled leaves. Fructification consisting of sporocarps borne on peduncles, which rise from the rootstock near the leaf-stalk or consolidated with it and containing both macrospores and microspores. Consisting of two genera both found in this country.

I. **Marsilia** L. Sporocarps ovoid; leaves quadrifoliate.

II. **Pilularia** L. Sporocarps globose; leaves filiform.

I. MARSILIA L.

Sporocarps ovoid or bean-shaped, composed of two vertical valves having several transverse compartments or sori in each valve, the sori composed of both macrosporangia and microsporangia. Sporocarps also provided with a ring which at the opening of the valves swells and tears the sori from their position. Leaves quadrifoliate on slender petioles; the sporocarps peduncled and rising from the petiole or from the rootstock at the base of the petiole. Named for *Aloysius Marsili*, an early Italian naturalist. Contains about 40 species, four occurring within our limits.

* *Sporocarps 2—6 on each peduncle.*

1. **M. quadrifolia** L. Plant usually slender, 5—12 cm. high; leaflets variable, 4—14 mm. wide, 5—15 mm. long, margins entire, smooth, or rarely with scattered hairs when young; sporocarps 2 (rarely 3) on a branching peduncle, which is usually attached to the stipe near its base, but sometimes as much as 2 cm. above; young sporocarp with short yellowish-brown hairs, later becoming naked and dark purple; lower tooth obtuse, upper small, acute or obtuse; sori, 8 or 9 in each valve. Bantam Lake, Litchfield County, Connecticut (*Dr. T. F. Allen*), from whence it has been cultivated in several localities.

2. **M. macropoda** Engelm. Plant robust, 10—25 cm. high; leaflets large, 2—5 cm. long, 2 cm. wide or less, usually undulate, clothed with white hairs on both sides when young, becoming smoother with age; sporocarps 2—6, on erect branching peduncles, ascending, densely villose, 6—8 mm. long, 5—6 mm. wide; raphe short, the lower tooth obtuse, the upper in-

conspicuous or wanting; sori, 10 in each valve. (*M. macropus* A. Br.) Texas, New Mexico.

** *Sporocarps* 1 (*rarely* 2) *on each peduncle.*

3. **M. uncinata** A. Br. Plant 6—20 cm. high; leaflets nearly smooth, entire, 10—16 mm. long; sporocarps 6 mm. wide, 8 mm. long; peduncles 15—30 mm. long, 2—4 times the length of the sporocarps; raphe long, terminating in two approximate teeth, the upper longer and mostly uncinately curved; sori, 13—14 in each valve. Western Louisiana (*Hale*), Dallas, Texas (*Reverchon*).

4. **M. vestita** Hook. & Grev. Plant 3—6 cm. high; leaflets entire or slightly toothed; sporocarps 4—7 mm. long, 3—5 mm. wide; raphe short, lower tooth short and blunt, the upper acute, a little longer, sometimes curved; paleæ varying from soft, dense and spreading to short and appressed, in *mucronata* forms, where it is sometimes wanting; sori, 6—11 in each valve, a very variable species. (Includes *M. mucronata* A. Br.) Arkansas (*Nuttall*), Kansas (*Watson*), Texas, Arizona (*Lemmon*), California, Nevada (*Watson*), Oregon (*Hall*), Washington, Montana *Watson*), Dakota (*Nicollet*), Florida (*Underwood*).

Var. **tenuifolia** (Engelm.) Unde. & Cook. Plant slender, 5—15 cm. high; leaflets narrow (2—4 mm. wide), more or less falcate, the apex often somewhat truncate and unequally toothed, villose with appressed hairs; sporocarps single, 5—8 mm. long, 4—5 mm. wide, the teeth divergent, subequal; sori, 9—11 in each valve. (*M. tenuifolia* Engelm. and former edition.) Pierdenales, Texas (*Lindheimer*), Western Texas (*Wright*).

II. PILULARIA L. Pillwort.

Sporocarps globose, longitudinally 2—4 celled, dehiscent from the apex; cells with parietal cushions bearing in the upper portion microsporangia and below these numerous macrosporangia containing solitary macrospores. Leaves filiform from a slender creeping rootstock, the sporocarps subsessile or peduncled or in the axils of the leaves. Named from Lat. *pilula*, a pellet. Includes six species widely distributed.

1. **P. Americana** A. Br. Leaves setiform, 1′ long; sporocarps 1″ in diameter, attached by the side to a short, descend-

ing peduncle, 3—4-celled; macrospores 13—17 in each cell, not constricted in the middle. Santa Barbara, California (*Mrs. Cooper*), Arkansas (*Nuttall*).

ORDER III. SALVINIACEÆ.

Floating plants with a more or less elongate and sometimes branching axis bearing apparently distichous leaves. Sporocarps soft, thin-walled, two or more on a common stalk, 1-celled, with a central, often branched receptacle which bears macrosporangia containing a single macrospore, or microsporangia containing numerous microspores. Consists of the two following genera.

I. **Salvinia** Schreb. Leaves 6″—9″ long, with a distinct midrib.

II. **Azolla** Lam. Leaves minute, numerous, closely imbricate, deeply lobed.

I. SALVINIA Schreb.

Floating annuals with slender stems bearing small two-ranked leaves. Sporocarps arranged in clusters, globose, membranous, 1—2 of each cluster containing 10 or more macrosporangia, the others containing numerous smaller microsporangia. Named for *Salvini*, a Florentine professor. Contains thirteen species, one of which is found with us.

1. **S. natans** Hoffm. Leaves oblong, horizontal, rounded or slightly cordate at base, ½′—1′ long, bright green above, the under surface matted with brown, pellucid hairs; sporocarps 4—8 in a cluster. (*Marsilia natans* L.) Bois Brulé Bottoms, Perry County, Missouri (*Demetrio.*) Reported by Pursh from Central New York; the exact station unknown.

II. AZOLLA Lam.

Small, moss-like plants with pinnately branched stems covered with minute, imbricate, 2-lobed leaves, and emitting rootlets beneath. Sporocarps of two kinds, borne in the axils of the leaves. Smaller sporocarps ovoid, containing a single macrospore at the base. Larger sporocarps globose, producing from the base many pedicelled sporangia, containing several masses

of microspores. Named from Gr. ἄξειν, to dry, and ὄλλυμαι, to destroy. Includes five species.

1. **A. Caroliniana** Willd. Plants ¾′—1′ long, reddish or greenish; cuticle of macrospores finely granulate; masses of microspores with rigid septate processes. New York to Florida, Arizona and Oregon.

2. **A. filiculoides** Lam. Fronds 1′—2′ long, often erect-crowded; cuticle of macrospores with large discoid tubercles; masses of microspores with rigid processes without septa. La Honda, California, and possibly widely distributed in that state.

ORDER IV. OPHIOGLOSSACEÆ Lindl.

Plant-body consisting of stem and leaf, usually from a fleshy, sometimes bulbous root, straight or inclined in vernation. Sporangia formed of the interior tissue of the frond, spiked or panicled, naked, not reticulated, destitute of a ring, opening by a transverse slit into two valves discharging copious sulphur-colored spores. Prothallium (so far as known) subterranean, not green, monœcious. Contains three genera.

I. **Ophioglossum** L. Sporangia cohering in one or more simple spikes. Veins reticulate.

II. **Botrychium** Swz. Sporangia in pinnate or compound spikes or panicles. Veins free.

I. OPHIOGLOSSUM L. Adder-tongue.

Sporangia large, coriaceous, connate, coherent in two ranks on the edges of a simple spike. Veins anastomosing. Spores copious, sulphur-yellow. Name from Gr. ὀφις, a serpent, and γλοσσα, a tongue. Includes ten species, four in our limits.

§ 1. Euophioglossum. *Fertile spike single, arising from the base of the sterile segment.*

* *Sterile portion near the middle of the stalk.*

1. **O. vulgatum** L. Rootstock short, oblique; stalk 6′—12′ high, the sterile segment ovate or elliptical-oblong, 1½′—4′ long, somewhat fleshy, somewhat narrowed at the base, sessile; fertile spike 1′ or more long. (*O. Engelmanni* Prantl.) Maine to Kentucky, Tennessee, Texas and Arizona to Alaska.

** *Sterile portion near the base of the stalks.*

2. **O. crotalophoroides** Walt. Rootstock tuberous, 3″—5″

thick; stalk 3′—6′ high, the sterile segment ½′—1′ long, ovate, slightly petioled, the veins somewhat indistinct; fertile spike short and thick, 3″—6″ long. (*O. bulbosum* Michx., *O. vulgatum, var. crotalophoroides* D. C. Eaton.) Florida to Texas.

3. **O. nudicaule** Linn. f. Rootstock slightly tuberous; stalk 1′—4′ high, the sterile segment ½′—1½′ long, ovate or oblong, the veins indistinct; fertile spike linear-acuminate, 6″ long, the peduncle very slender. (*O. ellipticum* H. and G., *O. Californicum* Prantl, *O. vulgatum, var. nudicaule* D. C. Eaton.) Georgia and Florida to Southern California.

§ 2. CHEIROGLOSSA Presl. *Fertile spikes several, arising from the base of the sterile segment.*

4. **O. palmatum** Plumier. Rootstock fleshy, tuberous, covered with fine wool-like chaff; plant fleshy, 6′—2° high, the sterile segment cuneate at the base, 2—6 lobed or rarely entire, the lobes elongate and tapering; fertile spikes 1—8 or more, borne on the sides of the stipe just below the sterile segment or on its margin. Florida.

II. BOTRYCHIUM Swz. GRAPE-FERN.

Rootstock very short, erect, with clustered fleshy roots, the bud for the next year's growth usually imbedded in the base of the stipe. Sterile segment of frond pinnately or ternately divided or compound. Fertile segment 1—3 pinnate with double rows of sessile, naked sporangia. Veins free. Spores copious, sulphur-yellow. Name from Gr. *βοτρυς*, a bunch of grapes, alluding to the clustered sporangia. Contains ten species, of which seven are found in our limits.

§ 1. EUBOTRYCHIUM. *Bud enclosed in the base of the stalk.*

* *Vernation wholly straight.*

1. **B. simplex** Hitch. Plant 2′—7′ high, fleshy; sterile segment stalked, varying in insertion from near the rootstock to two thirds the height of the stem, ovate, obovate or oblong, entire, incised, or pinnately parted into 1—3 pairs of roundish or semi-lunate lobes; fertile spike long-stalked, simple or 1—2 pinnate; spores the largest of the genus, closely covered with small points; bud smooth; apex of both sterile and fertile segments erect. (Fig. 31.) Specimens

FIG. 31.—Vernation of *B. simplex* Hitchcock. (After Davenport.)

with the sterile segment composed of two or three pinnately incised divisions form the *var. compositum* Lasch. New England, New York and northward, the variety in Wyoming and California; Maryland (*J. B. Egerton*).

*** Vernation partly inclined in one or both portions.*

† *Buds smooth; sterile segments sessile or short-stalked; plant small, fruiting in early summer.*

2. **B. lunaria** (L.) Swz. (MOONWORT.) Plant 5′—8′ high fleshy; sterile segment nearly sessile, borne near the middle of the stalk, oblong, simply pinnate with 5—15 lunate or fan-shaped lobes which are crenate, incised, or entire, close and overlapping, or distant; fertile segment bi—tripinnate, panicled, about the height of the sterile. Apex only of sterile segment bent over and outside of the nearly straight fertile segment in vernation; divisions of sterile frond arranged nearly perpendicularly. (Fig. 32.) Connecticut, New York, Lake Superior, Colorado, and British Columbia.

FIG. 32.—Vernation of *B. lunaria* Swz. (After Davenport.)

3. **B. boreale** (Fries) Milde. Plant 2½′—7′, smooth, fleshy; sterile segment placed above the middle, sessile, cordate, ovate or deltoid, pinnately parted, acute; lowest segment spreading from a narrower base, ovate or cordate-ovate, acute, all entire, or here and there flabellately incised with acute lobes, or pinnately parted; secondary segments from a narrowed base, ovate, acute, serrate, the upper spreading, quickly decreasing, finally elliptical, acute; fertile segment bi—tripinnate, panicled. Apex of sterile segment bent over inside of the nearly erect fertile one in vernation; divisions of the sterile segment arranged on an angle. Unalaska.

4. **B. matricariæfolium** A. Br. Plant 2′—12′ high, usually fleshy; sterile segment placed above the middle, short-stalked or sessile, ovate or oblong, pinnately parted into ovate-oblong, obtuse, rounded, entire, incised, pinnatifid, or pinnately parted segments, the narrow divisions linear; fertile segment 1—3 pinnate, panicled, often very much branched; spores thickly covered with large rounded warts. Apex of both segments turned

down in vernation; sterile segment clasping the fertile with its apex overlapping the whole. (Fig. 33.) (*B. neglectum* Wood.) New England, New York, Ohio, and Mt. Peddo, Washington (*Suksdorf*).

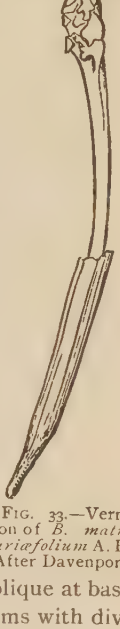

Fig. 33.—Vernation of *B. matricariæfolium* A. Br. (After Davenport.)

†† *Buds pilose; sterile segments usually long-stalked; plant larger, fruiting in autumn.*

5. **B. ternatum** (Thunb.) Swz. Frond fleshy, common stalk very short; sterile segment broadly pentagonal or triangular, ternate; the three primary divisions also stalked, as broad as long, pinnately decompound; ultimate divisions varying from round-reniform to triangular-lanceolate, entire or variously toothed and incised; fertile segment long-stalked, bi—quadripinnate. Apex of both segments bent down, with a slight curve inward in vernation. (Fig. 34.) (*B. australe* R. Br., *B. lunarioides* Swz., *B. fumarioides* Willd., *B. decompositum* Mart. and Gale., *Osmunda ternata* Thunb., *Botrypus lunarioides* Michx.) Very variable; larger forms (6′—17′ high), with more compound fructification and with divisions of sterile segment oblong or lanceolate and obtuse or oblique at base, are the *var. obliquum* Milde; forms with divisions of the sterile segment laciniately cut into narrow teeth are *var. dissectum* Milde. New England and Canada, westward to California, Washington, British Columbia, and southward to Florida.

Fig. 34.—Vernation of *B. ternatum* Swz. (After Davenport.)

**** Vernation wholly inclined, in the fertile segment recurved.*

6. **B. lanceolatum** (Gmel.) Angs. Plant 3′—9′ high, fleshy; sterile segment closely sessile at the top of a long common stalk, in the smallest forms three-lobed, in larger ones broadly triangular, twice pinnatifid, the divisions lanceolate, entire or toothed, all set at an oblique angle; fertile segment short-stalked, slightly overtopping the sterile, bi—tripinnate. Bud smooth;

the fertile segment recurved its whole length, the shorter sterile segment reclined upon it. (Fig. 35.) New England to Lake Superior and Colorado to Alaska.

FIG. 35.—Vernation of *B. lanceolatum* Angs. (After Davenport.)

§ 2. OSMUNDOPTERIS Milde. *Bud pilose, enclosed in a smooth upright cavity at one side of the lower part of the stalk.*

7. **B. Virginianum** (L.) Swz. (RATTLESNAKE-FERN.) Plant from a few inches to two feet high; sterile segment sessile above the middle of the stalk, broadly triangular, thinly herbaceous, ternate; the short-stalked primary divisions once to twice pinnate, then once or twice pinnatifid; lobes oblong, cut-toothed toward the apex; fertile segment long-stalked, bi—tripinnate. Bud pilose, enclosed in a smooth upright cavity at one side of the lower part of the stalk; fertile segment recurved its whole length, the longer sterile segment reclined upon it. Reduced forms are *B. gracile* Pursh. (*Botrypus Virginicus* Michx., *Osmunda Virginiana* L.) New Brunswick to Florida, and westward to Arizona and the Pacific Coast.

ORDER V. EQUISETACEÆ DC.

Plant body rush-like, often branched, with jointed, usually hollow stems rising from subterranean rootstocks, the sterile leaves reduced to sheaths at the joints, the fertile forming a short spike terminating the stem. Prothallium above ground, green, variously lobed, usually diœcious. Represented at present by only one genus.

I. EQUISETUM L. HORSE-TAIL. SCOURING-RUSH.

Perennial plants with extensively creeping rootstocks. Stems simple or branched, furrowed lengthwise, hollow, and provided with an outer circle of smaller cavities opposite the furrows as well as a second and smaller series opposite the ridges. Sporangia adhering to the under side of the shield-shaped scales of the spike, one-celled, opening down the inner side. Spores furnished with two slender filaments attached by the

middle. Name from Lat. *equus*, horse, and *seta*, a bristle. Contains about 25 species, widely distributed.

§ 1. EUEQUISETUM. *Stems annual, stomata scattered.*

* *Stems of two kinds, the pale or brownish fertile stems appearing earlier than the herbaceous sterile ones; fruiting in spring.*

† *Fertile stems simple, soon withering.*

1. **E. arvense** L. (HORSETAIL.) Sterile stems green, rather slender, 1°—2° high, 6—19 furrowed; branches numerous, long, mostly simple, 4-angled, minutely roughened, lowest joint commonly longer than the sheath of the stem; fertile stems 4'—10' high, light brown, the loose scarious sheath mostly distant, whitish, ending in about 12 brown acuminate teeth; spike rarely over 1' long. (*E. boreale* Bong.) Virginia to California and northward to Greenland.

2. **E. telmateia** Ehrh. Sterile stems ivory white or greenish, stout, 2°—6° high, 20–40 furrowed; branches very numerous, erect-spreading, simple, 4—5 angled, the ridges rough and sulcate, the lowest joint shorter than the sheath of the stem; fertile stems 10'—15' high, white, many-furrowed, the loose brownish sheaths elongate, deeply 20—30 toothed. (*E. fluviatile* Sm., *E. eburneum* Schreb., *E. maximum Auct.* not of Lam.) California, Oregon, and northward.

†† *Fertile stems when older producing herbaceous branches, only the naked apex withering.*

3. **E. pratense** Ehrh. Sterile and finally the fertile stems producing straight, simple branches; sheaths of the stem with about 11 short, ovate-lanceolate teeth, those of the branches 3-toothed. (*E. umbrosum* Willd., *E. triquetrum* Bory., *E. Drummondii* Hook.) Michigan, Wisconsin, and northward.

4. **E. silvaticum** L. Sterile and fertile stems usually 12-furrowed, producing compound branches, the branchlets curved downward; sheaths loose, those of the stem with 8—14 bluntish teeth, those of the branches with 4—5, and of the branchlets with 3 divergent teeth. Virginia to Michigan, and northward to Labrador.

** *Stems of one kind, herbaceous; branches simple or none; fruiting in summer.*

† *Sheaths somewhat loose.*

5. **E. palustre** L. Stems slender, 10′—18′ high, very deeply 5—9 grooved, the grooves separated by narrow, wing like ridges, roughish; sheaths with about 8 lance-awl-shaped, whitish margined teeth; branches few in a whorl, with mostly 5-toothed sheaths. (*E. pratense* Reichenb.) Western New York and Wisconsin to British Columbia and northward.

6. **E. litorale** Kuhl. Stems slightly roughened, 6—19 grooved, the carinæ convex; sheaths sensibly dilated above, the uppermost bell-shaped; leaves convex, angled beneath, separate at the commisural groove; teeth herbaceous, membranous at the margin, narrow, lanceolate; branches of two kinds, the 4-angled hollow, the 3-angled solid, first joint a little longer or shorter than the sheath of the stem; spores abortive, elaters usually wanting. Bay of Quinte, Canada (*Macoun*); Vermont (*Pringle*); Oswego River, New York (*Wibbe*).

†† *Sheaths appressed.*

7. **E. limosum** L. Stems 2°—3° high, slightly many-furrowed, smooth, usually producing upright branches after fructification; sheaths appressed, with about 18 dark-brown, short, acute, rigid teeth; air-cavities wanting under the grooves, small under the ridges. Includes *E. fluviatile* L. (*E. uliginosum* Muhl, *E. heleocharis* Ehrh.) Virginia to Washington Territory and northward.

§ 2. HIPPOCHÆTE. *Stems perennial, evergreen; spikes tipped with a rigid point; stomata in regular rows; fruiting in summer.*

* *Stems tall and stout, usually many-grooved.*

† *Branches numerous, regularly whorled.*

8. **E. ramosissimum** Desf. Stems grooved, more or less roughened, 6—26 furrowed; sheaths dilated, toothed; teeth not grooved, persistent or deciduous, leaving only a triangular, very rarely a truncated margin; leaves more or less distinct, 3—4 carinate; branches when present, 4—9 angled; series of stomata in 1—4 lines; inner bark of ridges higher than the grooves; ridges convex, marked with bands, never with two-rowed tubercles. Cuba (*Wright*), Mexico (*Schaffner*), British Columbia (*Lyall*), and probably will be found in the intervening territory.

†† *Branches few and irregular or wholly wanting.*

‡ *Stems rough, tuberculate.*

9. **E. robustum** A. Br. Stems 3°—11° high, and sometimes nearly 1′ thick, 20—48 furrowed; ridges roughened with a single series of transversely-oblong, siliceous tubercles; sheath short, cylindric, marked with black girdles at the base, and at the base of the caducous teeth; ridges of the sheaths tricarinate. Ohio to Louisiana, California and northward.

10. **E. hiemale** L. (SCOURING-RUSH.) Stems 1°—4° high, rough, 8—34 furrowed; ridges with two indistinct lines of tubercles; sheaths rather long, cylindric, marked with one or two black girdles; ridges of the sheath obscurely quadricarinate; teeth membranous, soon deciduous. North America generally.

‡‡ *Stems not tuberculate.*

11. **E. lævigatum** A. Br. Stems 1°—5° high, pale-green, 14—30 furrowed; the ridges almost smooth; sheaths elongate, enlarged upward, marked with a black girdle at the base of the mostly deciduous white margined teeth, and rarely also at the base of the sheath; ridges of the sheath with a central carina and sometimes with faint, short, lateral ones. North Carolina and Ohio to Louisiana, California and Oregon.

** *Stems slender, tufted, 5—10 grooved.*

12. **E. variegatum** Schleich. Stems ascending, 6′—18′ long, usually simple from a branched base, 5—10 furrowed; sheaths green, variegated with black above, the teeth 5—10, tipped with a deciduous bristle; central air-cavity small. Bellows Falls, New Hampshire (*Carey*), Niagara Falls to Illinois and northward to Greenland and Alaska.

13. **E. scirpoides** Michx. Stems filiform, very numerous, 3′—6′ high, flexuous and curving, mostly 6-furrowed, with acute ridges; sheaths 3-toothed, the bristle tips more persistent; central air-cavity wanting. New England to Pennsylvania, Illinois and northward.

ORDER VI. LYCOPODIACEÆ Lindl.

Moss-like, terrestrial plants with small, lanceolate or subulate, sometimes oblong or roundish, simple leaves, arranged in

two to many ranks on trailing or sometimes erect, usually branching stems. Sporangia 1—3 celled, solitary in the axils or the leaves, or on their upper surface. Spores of one kind, minute. Prothallia (so far as known) mostly subterranean, with or without chlorophyll, monœcious. Contains four genera, the following within our limits:

I. **Lycopodium** L. Leaves well developed, in 4—many ranks. Sporangia 1-celled.

II. **Psilotum** R. Br. Leaves minute, abortive. Sporangia 3-celled.

I. LYCOPODIUM L. Club-moss.

Perennial, terrestrial plants, with evergreen, one-nerved leaves arranged in 4—16 ranks. Sporangia coriaceous, flattened, reniform, one-celled, opening transversely, situated in the axils of ordinary leaves, or with fruit-bearing leaves modified into bracts which are arranged in spikes either sessile or peduncled. Spores copious, minute, sulphur-colored, inflammable. Named from Gr. λύκος, wolf, and ποῦς, foot, without obvious application. Contains nearly one hundred species.

§ 1. Plananthus Beauv. *Sporangia borne in the axils of leaves which are similar to those of the sterile and fertile stems.*

* *Sporangia usually wanting in axils of upper leaves; leaves dark-green, shining, about* 8*-ranked.*

1. **L. selago** L. Stems 3′—6′ high, thick, rigid, erect, 2—3 times forked, forming a level-topped cluster; leaves elongate-lanceolate, mucronulate, entire or spinulose-denticulate, nerved above, convex below. (*L. recurvum* Kit., *L. suberectum* Lowe, *Plananthus selago* Beauv.) Mountains of North Carolina to New England and Michigan, and northward to Alaska and Greenland.

2. **L. lucidulum** Michx. Stems ascending, thick, 2—3 times forked, the branches 6′—12′ high; leaves widely spreading or reflexed, flat, one-nerved, acute, minutely toothed. (*L. reflexum* Swz., *L. serratum* Desv., *Plananthus reflexus* Beauv.) North Carolina and northward.

** *Sporangia only in axils of upper leaves which form spikes; leaves many-ranked.*

3. **L. inundatum** L. Sterile stems creeping, flaccid, fork-

ing; fertile stems erect, simple, 1′—4′ high, bearing a short, thick spike; leaves lanceolate or lance-awl-shaped, acute, entire, soft, spreading or curved upward on prostrate stems. (*L. palustre* Lam., *Plananthus inundatus* Beauv.) Forms having the fertile stems 5′—7′ high, with more pointed, often tooth-bearing leaves, are the var. *Bigelovii* Tuckerm. (*L. Carolinianum* Bigel.) New England to Michigan and southward.

Var. **pinnatum** Chapm. Stems pinnately branched; leaves bristly-fringed below the middle, unequal, the upper and lower shorter and somewhat appressed, the lateral widely spreading; fertile stems 1° high, very leafy; spike thick, cylindric, 2′—3′ long. Western Florida.

4. **L. alopecuroides** L. Stems stout, densely leafy throughout; sterile branches flaccid, procumbent, creeping; fertile branches rigid, erect, 6′—20′ high, bearing a single spike; leaves narrowly linear-awl-shaped, spinulose-pointed, spreading, conspicuously bristle-toothed below the middle, nerved above, those of the cylindric spike with long, setaceous tips. (*L. longipes* H. & G., *Plananthus alopecuroides* Beauv.) New Jersey to Florida and Mississippi.

§ 2. EULYCOPODIUM. (LEPIDOTIS Beauv.) *Sporangia borne in the axils of yellowish, scale-like, imbricated, ovate or cordate leaves which form a distinct spike; leaves of sterile branches very unlike those of the spikes.*

* *Stems leafy to base of spikes, or nearly so.*

† *Spikes nodding.*

5. **L. cernuum** L. Stems erect, branching, the branches similar; leaves crowded, awl-shaped, incurved, terete in the middle, spreading, grooved below; bracts 8-ranked. (*L. marianum* Willd., *L. curvatum* Blume., *L. Boryanum* Richard, *L. bryifolium* Vent.) Florida, Southern Alabama.

†† *Spikes erect, closely sessile.*

6. **L. annotinum** L. Stems much branched, prostrate, creeping, 1°—4° long; the ascending branches similar, 5′—8′ high, sparingly forked; leaves equal, spreading, five-ranked, rigid, linear-lanceolate, minutely serrulate, nerved below; spike oblong, cylindric, thick. (*L. juniperifolium* Lam., *L. bryophyllum* Presl, *Lepidotis annotina* Beauv.) Mountain forms with

shorter and more rigid, pointed leaves are var. *pungens* Desv. (*L. reclinatum* Michx.) New England and New Jersey to Washington (State) and northward to Alaska and Greenland.

7. **L. obscurum** L. (GROUND-PINE.) Stems erect, 6′—9′ high, from a subterranean creeping rootstock, appearing flat from the leaves of upper side being appressed; leaves lanceolate-linear, acute, entire; spikes 4—10 on each plant; bracts many-rowed. (*Lepidotis dendroidea* Beauv.) Forms with the stems more tree-like, with spreading branches and leaves 4—6-ranked, are the var. *dendroideum* (*L. dendroideum* Michx.). Mountains of North Carolina to Canada, and northwestward to Indiana, Michigan, and Western North America.

8. **L. alpinum** L. Stems elongate, creeping, with ascending densely clustered branches; leaves 4-ranked, erect, imbricated, adnate-decurrent, of two forms; those of the lateral rows lanceolate, falcate, acute, carinate, concave within; those of the intermediate rows scarcely one third smaller, lance-awl-shaped, the upper and lower rows not different. (Possibly a form of *L. complanatum* L.) Lake Superior to Rocky Mountains; Mt. Peddo, Washington (*Suksdorf*), and Unalaska.

††† *Spikes erect, short-peduncled.*

9. **L. sabinæfolium** Willd. (GROUND-FIR.) Stems elongate, creeping, usually underground; branches erect, short, dichotomous, clustered; leaves 4-rowed, small, appressed, lanceolate, mucronate, entire, apparently terete; spikes cylindric, solitary, with cordate acuminate bracts. (*L. alpinum* Michx., *L. armatum* Desv.) New Jersey, New York, New England, and northwestward. This is sometimes united with *L. complanatum*.

***Fertile branches with minute leaves, so that the spikes appear long-peduncled.*

† *Leaves uniform, many-ranked; stems terete.*

10. **L. clavatum** L. (RUNNING-PINE.) Stems extensively creeping; branches similar, ascending, short and leafy, the fertile terminated by a slender peduncle bearing 1—4 linear, cylindric spikes; leaves much-crowded, linear-awl-shaped, tipped like the bracts with a fine bristle. (*L. officinale* Neck., *L. vulgare* Vaill., *L. inflexum* Swz., *L. serpens* Presl, *Lepidotis inflexa*

Beauv.) North Carolina to Canada and westward to Washington and Unalaska.

†† *Leaves of two forms, few ranked; stems flattened.*

11. **L. Carolinianum** L. Sterile stems and their few short branches entirely creeping; lateral leaves broadly lanceolate, acute, and somewhat oblique, one-nerved, widely spreading in 2-ranks; upper row of leaves shorter, appressed; peduncle simple, slender, 2′—4′ high, clothed with small bract-like leaves, bearing a single cylindric spike. (*L. repens* Swz., *L. affine* Bory., *Lepidotis repens* Beauv.) New Jersey to Florida, Alabama, and Louisiana.

12. **L. complanatum** L. Stems extensively creeping, with erect or ascending fan-like branches several times forked above; branchlets crowded, flattened; leaves minute, imbricate-appressed, 4-ranked; the lateral rows with somewhat spreading tips; the intermediate smaller, narrower, and wholly appressed; peduncle slender, bearing 2—4 cylindric spikes. (*L. thyoides* Humb. & Bonpl., *L. tristachyon* Pursh, *L. anceps* Wallr., *L. chamæcyparissus* A. Br., *Lepidotis complanata* Beauv.) North Carolina to New England, Michigan, and northward.

II. PSILOTUM R. Br.

Perennial plants, terrestrial or growing on trees. Stems dichotomously-branched with minute alternate leaves or apparently leafless. Sporangia sessile, 3-celled, opening at the apex into 2—3 valves. Spores farinaceous, oval or elongate-reniform, Name from Gr. *ψίλος*, naked, alluding to the abortive leaves. Contains four species, mostly tropical.

1. **P. nudum** (L.) Griseb. Stems erect, 8′—10′ high, triquetrous at base, many times forked at apex; ultimate divisions triquetrous-winged; leaves remote, awl-shaped, less than 1″ long; sporangia in spikes. (*P. Floridanum* Michx., *P. triquetrum* Swz., *Bernhardia dichotoma* Willd., *B. pedunculata* Desv., *Lycopodium nudum* L.) South Florida; Bluffton, South Carolina (*Mellichamp*).

ORDER VII. SELAGINELLACEÆ.

Plant-body leafy, terrestrial, moss-like, with branching stems and minute scale-like leaves. Sporangia one-celled, solitary, axillary, some containing microspores, and others macrospores. Contains a single genus largely tropical.

I. SELAGINELLA Beauv.

Fructification arranged in spikes. Sporangia minute, subglobose, opening transversely; some containing usually 4 globose macrospores, and others smaller, filled with numerous microspores. Leaves 4—many ranked. Name a diminutive of *Selago*, an ancient name of some species of *Lycopodium*, which this genus resembles. Contains about 335 species widely distributed; seven are found within our limits.

§ 1. EUSELAGINELLA. *Stem leaves of one kind, many-ranked; bracts uniform.*

* *Stems prostrate or spreading, somewhat rigid.*

1. **S. rupestris** (L.) Spring. Stems densely tufted, prostrate or ascending, much-branched, 2′—12′ long; leaves appressed imbricate, linear or linear-lanceolate, convex and sulcate dorsally, rigid, bristle-tipped, ciliate; spikes strongly quadrangular, 6″—12″ long; sporangia of both sorts in the same axils; macrosporangia abundant; bracts ovate-lanceolate. (*Lycopodium rupestre* L., *L. bryopteris* Wall.) New England to Florida, Texas, California, and northward.

Var. **tortipila** (A. Br.) Unde. Leaves sub-entire, gibbous near the apex; terminal bracts tipped with a long, twisted, white awn; macrospores loosely reticulate. Cæsar's Head, South Carolina (*J. D. Smith*); Negro Mountain, North Carolina (*Gray*).

2. **S. selaginoides** (L.) Link. Sterile stems prostrate-creeping, small and slender; fertile stems thicker, ascending, simple, 1′—3′ high; leaves lanceolate, acute, spreading, sparsely spinulose-ciliate; bracts lax, ascending, lanceolate or ovate-lanceolate, strongly ciliate. (*S. spinosa* Beauv., *Lycopodium selaginoides* L., *L. ciliatum* Lam.) New Hampshire to Colorado and northward to Greenland.

** *Stems pendent, flaccid.*

3. **S. Oregana** D. C. Eaton. Stems 1°—6° long, pinnately

much branched; leaves loosely imbricate, scarcely 1″ long, linear-lanceolate, convex and grooved on the back, acute, sparsely spinulose-denticulate, not bristle-tipped; spikes quadrangular, very slender; macrosporangia scarce. Port Orford, Oregon (*Kautz*); Tilamook Valley, Oregon (*Howell*); probably in Northern California.

§ 2. STACHYGYNANDRUM Baker. *Stem leaves of two kinds, spreading in two planes, those of the upper plane smaller and more ascending; bracts uniform.*

* *Main stems decumbent; root fibres extending to upper nodes.*

† *Stems persistent; leaves rigid, firm in texture.*

4. **S. Douglasii** (H. & G.) Spring. Stems 3′—12′ long; branches 2′—6′ long, bi—tripinnately divided; leaves of lower plane 1″ long, obliquely oval, obtuse, faintly nerved; leaves of upper plane half as long, oval, incurved, ending in a short point, both sparingly ciliate at base; spikes 6″—12″ long, quadrangular, terminal; bracts deltoid-cuspidate, strongly imbricate. (*Lycopodium Douglasii* H. & G., *L. ovalifolium* H. & G.) Northern California to British Columbia.

†† *Stems mostly annual, fugacious; leaves mostly membranous, flaccid.*

5. **S. apus** (L.) Spring. Stems 1′—4′ long, slender, angled on the face, prostrate, creeping, much-branched, flaccid; leaves of the lower plane spreading above, the lower reflexed, ovate, acute, serrulate, not distinctly ciliate; leaves of the upper plane ovate, shortly cuspidate; spikes 3″—6″ long; bracts ovate, acute, membranous, strongly serrulate, acutely keeled in the upper half. Canada and New England to Rocky Mountains, and southward to Florida and Texas.

6. **S. Ludoviciana** A. Br. Stems slender, copiously pinnate, flat both sides, 4′—6′ long, lower branches slightly compound; leaves of lower plane rather distant except at tips of branches, spreading, ovate-oblong, sub-acute, firmer in texture than in preceding, serrulate, not distinctly ciliate; leaves of upper plane half as long, obliquely oblong, cuspidate; spikes 3″—6″ long; bracts ovate-lanceolate, strongly keeled. (*S. apus*, var. *denticulata* Spring, where it may belong, the differences possibly due to climatic conditions.) Covington, Louisi-

ana (*Drummond*); Aspalaga, Florida (*Curtiss*, No. 3799 in part).

** *Stems densely tufted, rolling into a nest-like ball when dry; roots confined to base of stems.*

7. **S. lepidophylla** Spring. Stems 2′—4′ long, densely tufted, pinnately branched to the base, the pinnæ ascending, sub-flabellately compound; leaves of the lower plane closely imbricate, ascending, obliquely ovate, obtuse, thick, rigid, minutely ciliate, green above, paler below, becoming reddish-brown in age; leaves of upper plane nearly as long, obliquely ovate, obtuse; spikes 3″—6″ long, quadrangular; bracts deltoid, acutely keeled. Texas to Arizona.

8. **S. Pringlei** Baker. Outer stems 3′—4′ long, the inner gradually shorter, flabellately branched, light green above, pale below; branchlets close, 1″—2″ wide; leaves of the lower plane crowded, oblong, about 1′ long, including the conspicuous horny white awn; leaves of upper plane slightly smaller, somewhat oblique; spikes short with uniform bracts. Chenate Mountains, Texas (*Nealley*).

S. pilifera A. Br. is reported by Mr. Baker from Texas, but it has not been found there recently.

ORDER VIII. ISOETACEÆ.

Plant-body consisting of a bilobed or trilobed trunk emitting dense tufts of roots, and sending up a compact rosette of rush-like leaves, submerged, amphibious or sometimes growing in moist soil. Sporangia sessile in the axils of the leaves, some containing macrospores and others microspores. Contains a single genus widely distributed.

I. ISOETES L. Quillwort.

Stem or trunk a more or less depressed, fleshy corm, rooting just above its bilobed or trilobed base, covered above with the dilated and imbricated bases of the awl-shaped or linear leaves. Sporangia large, orbicular or ovoid, plano-convex, very thin, sessile in the axils of the leaves and united at the back with their excavated bases; those of the outer leaves filled with spherical macrospores; those of the inner leaves filled with minute and powdery, grayish, obliquely oblong and triangular

microspores. Name from Gr. ισος, equal, and ετος, year. Contains about 50 species, of which sixteen are found within our limits.

NOTE.—The measurements of the spores are given in millimetres; mm. = .03937 inch.

§ 1. *Submerged, rarely above water in driest seasons; leaves quadrangular without peripheral bast-bundles; velum incomplete.*

* *Stomata absent.*

1. **I. lacustris** L. Leaves 10—25, stout, rather rigid, obtusely quadrangular, acute but scarcely tapering, dark or olive-green, 2′—6′ long; sporangia orbicular—broadly-elliptic, with a narrow velum; ligula triangular, short or somewhat elongate; macrospores 0.50—0.80 mm. in diameter, marked all over with distinct or somewhat confluent crests; microspores smooth, 0.035—0.046 mm. long. Var. *paupercula* Engelm. has fewer, thinner and shorter leaves and smaller spores, the microspores somewhat granulate, 0.026—0.036 mm. long. (*I. macrospora* Durieu.) Catskill Mountains, New York (*Schweinitz*), Echo Lake, New Hampshire (*Tuckerman*), Fresh Pond, near Cambridge, Massachusetts (*W. Boott*), Uxbridge, Massachusetts (*Robbins*), Brattleborough, Vermont (*Frost*), Lake Superior (*Porter*). The variety from Grand Lake, Middle Park, Colorado (*Engelmann*) and Castle Lake near Mt. Shasta, California (*Pringle*).

2. **I. pygmæa** Engelm. Leaves 5—10, stout, rigid, bright-green, ½′—1′ long, abruptly tapering to a fine point, with very short often almost square epidermal cells; sporangia orbicular with a narrow velum; macrospores 0.36—0.50 mm. thick, marked with minute, rather regular, distinct or rarely confluent warts; microspores brown, almost smooth, 0.024—0.029 mm. long. Mono Pass, California (*Bolander*).

3. **I. Tuckermani** A. Br. Leaves 10—30, very slender, tapering, olive-green, 2′—3′ long, the outer recurved; sporangia mostly oblong, white or rarely brown-spotted, the upper third covered by the velum; macrospores 0.44—0.56 mm. thick, the upper segments marked with prominent, somewhat parallel and branching ridges, the lower half reticulate; microspores smooth

or nearly so, 0.026—0.032 mm. long. Mystic River, Mystic, Spy, and Horn Ponds, near Boston, Massachusetts.

** *Stomata present.*

4. **I. echinospora** Durieu, *var.* **Braunii** (Dur.) Engelm. Leaves 13—15, erect or spreading, tapering, green or reddish-green, 3′—6′ long, generally with few stomata toward the tip only; sporangia orbicular—broadly-elliptic, spotted, ½ to ¾ covered by the broad velum; macrospores 0.40—0.50 mm. thick, covered with broad, retuse spinules, sometimes somewhat confluent and then dentate and incised at the tip; microspores 0.026—0.030 mm. long, smooth. (*I. Braunii* Durieu.) Nova Scotia, New England, New York, New Jersey, Pennsylvania, Ontario, Michigan (*Gillman*), Head of Bear River, Utah (*Watson*), Greenland (*Vahl*).

Var. **robusta** Engelm. Stouter; leaves 25—70, 5′—8′ long, with abundant stomata all over their surface; velum covering one half of the large, spotted sporangia; macrospores 0.36—0.55 mm. thick. Lake Champlain, north end of Isle La Motte (*Pringle*).

Var. **Boottii** (A. Br.) Engelm. Leaves 12—20, erect, bright-green, 4′—5′ long, with few stomata mostly near the tip; sporangia nearly orbicular, pale-spotted, ⅔ or more covered by the broad velum; macrospores 0.39—0.50 mm. thick, with longer, more slender and delicate, generally simple spinules; microspores 0.026—0.030 mm. long. (*I. Boottii* A. Br.) Round Pond, Woburn, and in brook in Tofit Swamp, Lexington, Massachusetts (*Bootf*).

Var. **muricata** (Dur.) Engelm. Leaves 15—20, flaccid, green, 6′—12′ long, with very few stomata; sporangia broadly oval, pale-spotted, about half covered by the velum; macrospores 0.40—0.58 mm. thick, with shorter and more confluent, sometimes almost crest-like spinules; microspores 0.028—0.032 mm. long, slightly rough on the edges. (*I. muricata* Durieu.) Woburn Creek and Abajona river near Boston, Massachusetts (*Bootf*).

5. **I. Bolanderi** Engelm. Leaves 5—25, erect, soft, bright-green, tapering to a fine point, 2′—4½′ long, with thin walls and generally few stomata; sporangia broadly oblong, mostly unspotted, with a narrow velum; ligula triangular; macrospores

0.30—0.45 mm. thick, marked with minute low tubercles, rarely confluent into wrinkles; microspores deep-brown, 0.026—0.031 mm. long, spinulose, rarely smooth. (*I. Californica* Engelm.) Western Colorado (*Brandegee*), Utah, California, to Washington.

§ 2. *Amphibious, partially emerged; stomata always present.*

* *Peripheral bast-bundles absent.*

† *Velum partial.*

6. **I. saccharata** Engelm. Trunk usually flat, depressed; leaves 10—20, awl-shaped, spreading, olive-green, 2′—3′ long; sporangia oblong, spotted, with a narrow velum; ligula triangular; macrospores 0.40—0.47 mm. thick, covered with very minute, distinct warts, which are sometimes a little confluent; microspores papillose, 0.024—0.028 mm. long. Banks of Wicomico river, below Salisbury, and of Nanticoke river, Eastern Maryland (*Canby*).

7. **I. riparia** Engelm. Leaves 15—30, slender, rather rigid, deep-green, 4′—8′ long, with numerous stomata; sporangia mostly oblong, distinctly brown-spotted, ¼ or ⅓ covered by the velum; macrospores 0.45—0.65 mm. thick, marked with isolated or anastomosing, jagged crests; microspores more or less tuberculate, 0.028—0.032 mm. long. Banks of Delaware River from Burlington to Wilmington, Delaware; Uxbridge, Massachusetts (*Robbins*); Brattleborough, Vermont (*Frost*); Maine (*Chickering*); Crow River, Hastings County, Ontario (*Macoun*).

†† *Velum complete.*

8. **I. melanospora** Engelm. Trunk flat, only slightly bilobed; leaves 5—10, distichous, slender, tapering, light-green, 2′—2½′ long; sporangia orbicular or almost obcordate, ½″—1″ long, entirely covered by the velum; ligula short triangular, obtuse; macrospores 0.35—0.45 mm. long, roughened with distinct or rarely somewhat confluent warts, dark-colored; microspores smoothish or slightly papillose, 0.028—0.031 mm. long. In shallow excavations in granite rock, Stone Mountain, Georgia (*Canby*).

** *Peripheral bast-bundles present.*

† *Velum partial or entirely wanting.*

9. **I. Engelmanni** A. Br. Leaves 25—100, light-green,

9′—20′ or more long, with abundant stomata; sporangia oblong—linear-oblong, unspotted, with a narrow velum; ligula elongate from a triangular base; macrospores 0.40—0.52 mm. thick, delicately honeycomb-reticulated; microspores usually smooth, 0.024–0.028 mm. long. Var. *Georgiana* Engelm. has fewer leaves and larger (0.48—0.56 mm. thick) macrospores. New England and New York, Missouri and Illinois; the variety in Horseleg Creek, Floyd County, Georgia (*Canby*).

Var. **gracilis** Engelm. Leaves 8—12, often submerged, 9′—12′ long, the bast bundles often quite small or only two present. New England; Passaic River, New Jersey (*Ennis*).

Var. **valida** Engelm. Leaves 50–200, keeled on the upper side, 18′—25′ long; sporangia often linear-oblong 4″—9″ long, ⅛ to ⅔ covered by the broad velum; macrospores 0.32—0.48 mm. thick; microspores spinulose, 0.024–0.027 mm. long. Warrior's Mark and Smithville, Pennsylvania (*Porter*); Wilmington, Delaware (*Canby*).

10. **I. Howellii** Engelm. Leaves 10—25, bright-green, 5′—8′ long, with thick dissepiments; sporangia oval, 1⅓″—2⅔″ long, unspotted, ⅓ to ½ covered by the velum; ligula awl-shaped, as long as the sporangium; macrospores 0.43–0.48 mm. thick, rough with prominent, rounded, single or sometimes confluent tubercles. Dalles of the Columbia, Oregon (*Howell*).

11. **I. nuda** Engelm. Leaves 10—15, bright-green, 6′—9′ long; sporangia oval, light-brown, attached to the base of the leaves by the median line only, the velum entirely wanting; ligula somewhat triangular; macrospores 0.366—0.4 mm. thick, slightly tuberculate, the tubercles somewhat confluent. Hood River, Oregon (*Howell*).

†† *Velum complete.*

12. **I. flaccida** Shuttleworth. Leaves 10—35, light-green, 15′–2° long, submerged, floating on the surface or wholly emerged; sporangia oval, 2″—3″ long, entirely covered by the velum; macrospores 0.30–0.42 mm. thick, covered with many or rarely few, large flattish tubercles, distinct or confluent into labyrinthiform wrinkles. Var. *rigida* Engelm. is smaller, with more slender, erect, dark-green leaves, 5′—6′ long. Lake Immonia, near Tallahassee, Florida (*Rugel*); also near Manatee, Florida (*Garber*). The variety at Lake Flirt, Florida (*Garber*).

Var. **Chapmani** Engelm. Leaves about 30, floating, 18′ long; sporangia orbicular; macrospores 0.44—0.55 mm. thick, almost smooth on the upper side; microspores slightly papillose, 0.027—0.030 mm. long. Near Mariana, Florida (*Chapman*).

§ 3. *Terrestrial; leaves nearly triangular, with abundant stomata and peripheral bast-bundles, thick dissepiments and small air-cavities.*

* *Trunk bilobed.*

† *Velum partial or almost wanting.*

13. **I. melanopoda** J. Gay. Polygamous; trunk sub-globose, deeply bilobed; leaves 15—60, slender, stiff, erect, bright-green, usually black at base, 5′—10′ or more long; sporangia mostly oblong, 2″—5″ long, spotted, with a narrow velum; ligula triangular awl-shaped; macrospores 0.25—0.40 mm. thick, with depressed tubercles often confluent into worm-like wrinkles, or almost smooth; microspores spinulose, 0.023—0.028 mm. long. Var. *pallida* Engelm. is larger, with pale leaf-bases and broader velum. Ringwood and Athens, Illinois (*Hall*); Clinton, Iowa (*Vasey*); Limestone Gap, Indian Territory (*Butler*). The variety at Houston, Texas (*Hall*).

14. **I. maritima** Unde. Monœcious; trunk small, only slightly bilobed; leaves 8—15, rigid, green, 1′—2′ long, ½″—⅔″ wide; sporangia oval, 2″ long, 1¼″ wide, brownish white, one third to one half covered by the velum; ligula small; macrospores 0.42—0.48 mm. thick, densely spinulose, the spines blunt, rarely confluent; microspores smooth, white, 0.32—0.35 mm. thick. In salt marsh, Alberni, Vancouver Island (*Macoun*).

15. **I. Butleri** Engelm. Dioœcious; trunk sub-globose; leaves 8—12, rigid, bright-green, 3′—7′ long; sporangia usually oblong, spotted, with a very narrow velum or none; ligula awl-shaped from a triangular base; macrospores 0.50—0.63 mm. thick, marked with knobs or warts, distinct or sometimes confluent; microspores papillose, dark-brown, 0.028—0.038 mm. long. Var. *immaculata* Engelm. is larger, with unspotted sporangia, and spinulose microspores, the macrospores 0.40—0.56 mm. In saline flats, near Limestone Gap, Indian Territory

(*Butler*), near St. Louis, Missouri (*Eggert*). The variety in cedar barrens, near Nashville, Tennessee (*Gattinger*).

†† *Velum complete.*

16. **I. Nuttallii** A. Br. Trunk almost globose, slightly grooved; leaves 20—60, slender, bright-green, 3′—9′ long, with only three peripheral bast-bundles; sporangia oblong or oval, entirely covered by the velum; macrospores variable, 0.25—0.50 mm. thick, densely covered with minute but rounded warts, or rarely almost smooth; microspores papillose, brown, 0.025—0.028 mm. long. (*I. opaca* Nutt.) Oregon, Washington; Western Idaho (*Geyer*), Vancouver Island (*Macoun*).

** *Trunk trilobed; velum complete.*

17. **I. Suksdorfii** Baker. Leaves 12—20, firm, bright-green, very slender, arcuate, deeply channelled along the face, 2′—3′ long, less than $\frac{1}{2}$″ wide; sporangia orbicular, 2″ long and broad; ligula deltoid; macrospores grayish-white, faintly granulated. W. Klickitat County, Washington (*Suksdorf*, No. 836), California (*Brandegee*).

GLOSSARY AND INDEX.

A

Acrogenous (Gr. *ἄκρον*, the highest part, and *γέννᾰν*, to produce), pertaining to plants whose growth takes place at the summit. Includes Ferns, Mosses, etc.

Acrosticheæ, 76.

Acrostichum, 89; also 5, 6, 12, 76.

Aculeate (Lat. *aculeus*, diminutive of *acus*, a needle), armed with prickles.

Adder-tongue. *Vide* **Ophioglossum.**

Adiantum, 89; also 5, 13, 42, 73, 77.

Adnate (Lat. *ad*, to, *nasci*, to be born), growing fast to some other portion of the plant.

Algæ, 49.—Literature of, 55.

Allosorus. *Vide* **Cryptogramme.**

Analogy (Gr. *ἀνα*, according to; *λόγος*, ratio, proportion), similarity in function; distinguished from *homology*, indicating similarity in structure.

Anastomose (Gr. *ἀναστομοῦν*, to open into), forming a net-work; said of veins which unite with each other.

Aneimia, 123; also 18, 79.

Annulus (Lat. a ring), the ring partly or completely surrounding the sporangium.

Antheridium (plu. *antheridia*) (Lat. *anthera*, an anther, and Gr. *εἶδος*, form), the part containing the male element. 20.

Antherozoid (Lat. *anthera*, an anther; Gr. *ζῷον*, an animal, and *εἶδος*, form), the male element of cryptogams. 20.

Archegonium (plu. *archegonia*) (Gr. *ἀρχή*, beginning, and *γονή*, offspring), the part containing the female element. 20.

Arcuate (Lat. *arcus*, a bow), curved like a bow.

Areola (plu. *areolæ*). (Lat. diminutive of *area*, an open place), a space enclosed by anastomosing veinlets.

Asexual Reproduction in Ferns. 27.

Aspidieæ, 78.

Aspidium. *Vide* **Dryopteris**, 16, 78.

Asplenieæ, 78.

Asplenium, 103; also 2, 3, 5, 6, 15, 27, 78.

Auriculate (Lat. *auricula*, a little ear), furnished with ear-like appendages.

Azolla, 127; also 39.

B

Beech-fern. *Vide* **Phegopteris.**

Bi (Lat. *bis*, twice), (as a prefix) two, twice or doubly.

Bladder-fern. *Vide* **Cystopteris.**

Blechneæ, 77.

Blechnum, 102; also 15, 77.

Botrychium, 129; also 2, 3, 5, 19, 29, 30.

Brake or **Bracken.** *Vide* **Pteris.**

Bryophytes (Gr. *βρύον*, moss, and *φυτόν*, plant), 52.

Buds, borne on ferns, 27.

Bulblets borne on ferns, 27.

C

Calamariaceæ, 67.

Camptosorus, 108; also 3, 6, 9, 16, 27, 78.

Carboniferous Age, Pteridophytes of, 68.

Carinate (Lat. *carina*, a keel), keeled.
Carpophyta (Gr. καρπός, fruit, and φυτόν, plant).
Castaneous (Lat. *castanea*, a chestnut), chestnut-colored.
Caudate (Lat. *cauda*, a tail), furnished with a slender appendage resembling a tail.
Caudex (Lat. a stem), the upright rootstock forming the trunk of a tree-fern, 8.
Cellulose (Lat. *cellula*, a little cell), the substance composing the wall of cells, containing the elements carbon, hydrogen, and oxygen.
Ceraceous (Lat. *cera*, wax), having the nature of wax.
Ceratopterideæ, 77.
Ceratopteris, 101; also 6, 14, 77.
Characeæ, 51.—Literature of, 56.
Chartaceous (Lat. *charta*, a leaf of paper), having the texture of paper or parchment.
Cheilanthes, 91; also 3, 6, 8, 13, 26, 43, 77.
Chlorophyll (Gr. χλωρός, green, and φύλλον, leaf), the green grains forming the coloring matter of plants.
Christmas-fern. *Vide* **Dryopteris.**
Ciliate (Lat. *cilium*, an eyelash), having on the margin a fringe of hairs resembling the fringing eyelashes.
Cinnamon-fern. *Vide* **Osmunda.**
Circinate (Lat. *circinus*, a pair of compasses), rolled inward from the apex, 8.
Classification of the Vegetable Kingdom, 48.—Principle of, 45.
Cliff-brake. *Vide* **Pellæa.**
Climbing-fern. *Vide* **Lygodium.**
Cloak-fern. *Vide* **Notholæna.**
Club-moss. *Vide* **Lycopodium.**
Confluent (Lat. *con*, together, and *fluere*, to flow), blended together.
Connate (Lat. *con*, together, and *nasci*, to be born), united together from the first.
Cordate (Lat. *cor*, the heart), heart-shaped.
Coriaceous (Lat. *corium*, a hide), leathery.
Cotton-fern. *Vide* **Notholæna.**
Crenate (Lat. *crena*, a notch), having the margin scalloped with rounded teeth.
Crenulate (Lat. *crenula*, a little notch), scalloped with small rounded teeth.
Cryptogamia (Gr. κρυπτός, hidden, γάμος, marriage), flowerless plants; an obsolete term.
Cryptogramme, 97; also 2, 14, 77.
Cultivation, Literature of, 7.
Cuneate (Lat. *cuneus*, a wedge), wedge-shaped.
Cystopteris, 118; also 4, 5, 6, 16, 27, 78.

D

Decurrent (Lat. *de*, down, and *currere*, to run), prolonged on the rachis.
Deer-fern. *Vide* **Lomaria.**
Deltoid (Gr. δέλτα, the letter D, and εἶδος, form), triangular, like the Greek delta.
Dentate (Lat. *dens*, a tooth), toothed.
Denticulate (Lat. *denticulus*, diminutive of *dens*, tooth), finely toothed.
Desmidiaceæ, 50.—Literature of, 56.
Determination of Species, 68.
Devonian Age, Pteridophytes of, 66.
Diatomaceæ, 50.—Literature of, 56.
Dichotomous (Gr. δίχα, asunder, and τέμνειν, to cut), two-forked.
Dicksonia, 121; also 3, 5, 7, 17, 79.
Dicksonieæ, 79.
Dimorphism, 3.—Literature, of 3.

Dimorphous (Gr. δίς, twice, and μωρφή, shape, form), of two forms; said of ferns whose fertile fronds are unlike the sterile.

Dicœcious (Gr. δίς, twice, and οἶκος, house), bearing the male and female organs on different plants.

Distichous (Gr. δίς, twice, and στίχος, a row), disposed in two rows

Distribution, Geographic, 62.—Geologic, 67.—Local, 4.

Dryopteris, 110; also 2, 5, 7, 8, 10, 11, 16, 26, 42, 68, 73.

E

Ebeneous (Lat. *ebenus*, ebony), black like ebony.

Elater, the spirally coiled appendages of the spores of *Equisetum*.

Endospore (Gr. ἔνδον, within, and σπορός, a seed), the inner wall of the spore.

Epidermis (Gr. επι, upon, and δέρμα, the skin), the external covering of the plant.

Epiphytic (Gr. επι, upon, and φυτόν, a plant), growing upon another plant, but not nourished by it.

Equisetaceæ, 132; also 31.—Literature of, 34.

Equisetum, 132; also 31, 33, 69.

Exospore (Gr. ἔξω, outside, and σπορός, a seed), the external covering of the spore.

F

Falcate (Lat. *falx*, a sickle), scythe-shaped; slightly curved upward.

Farinose (Lat. *farina*, ground corn), covered with a white or yellowish powder.

Fern Allies, 28.

Fern Structure, Literature of, 28

Ferns, Artificial Synopsis of genera of, 80.—Mode of growth, 2.—Time of fruiting, 4.—Variation in, 2.

Ferruginous (Lat. *ferrum*, iron), resembling iron rust.

Fertilization, 21.

Fibrillose (Lat. *fibra*, a thread), formed of small fibres.

Filices, 75.

Filiform (Lat. *filum*, a thread, *forma*, form), thread-like.

Flabellate (Lat. *flabellum*, a fan), fan-shaped; broad and rounded at the summit and narrow at the base.

Flaccid (Lat. *flaccus*, flabby), soft and weak.

Floating-fern. *Vide* **Ceratopteris.**

Flowering-fern. *Vide* **Osmunda.**

Foliaceous (Lat. *folium*, a leaf), having the nature of a leaf.

Fovea (Lat. a small pit), the depression in the leaf of *Isoëtes* containing the sporangium.

Frond (Lat. *frons*, a leafy bough), that which answers to the leaf in ferns, 8, 26.

Fructification of Ferns, 10; of Ophioglossaceæ, 30; of *Equisetum*, 33; of Club-mosses, 35; of *Isoëtes*, 38; of *Marsilia*, 39; of *Pilularia*, 39; of *Azolla*, 39; of *Salvinia*, 40.

Fulvous (Lat. *fulvus*, reddish-yellow), tawny.

Fungi, 49.—Literature of, 56.

G

Gasteromycetes, 52.—Literature of, 59.

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Glabrous (Lat. *glaber*, smooth) smooth.

Glanduliferous (Lat. *glandula*, a little kernel, and *ferre*, to bear), furnished with glands.

Glaucous (Gr. γλαυκός, sea-green), covered with a bloom like a plum.

Globose, spherical in form or nearly so.

Goethe on species, 43.

Gold-fern. *Vide* **Gymnogramme.**
Grammitideæ, 76.
Grape-fern. *Vide* **Botrychium.**
Ground-pine, Ground-fir, etc. *Vide* **Lycopodium.**
Gymnogramme, 84; also 3, 9, 13, 41, 68, 76.

H

Hartford-fern. *Vide* **Lygodium.**
Hart's-tongue. *Vide* **Scolopendrium.**
Hastate (Lat. *hasta*, a spear), furnished with spreading lobes on each side at the base.
Helvellaceæ, 52.—Literature of, 60.
Hepaticæ, 52. — Literature of, 61.
Herbaceous (Lat. *herba*, an herb), having the texture of common herbage.
Heterosporous (Gr. ἕτερος, other and σπορός, a seed), producing two kinds of spores, as in *Selaginella*, *Marsilia*, etc.
Histology (Gr. ἱστός, web, tissue, and λόγος, a discourse), the study of the microscopic characters of the tissues of plants and animals.
Holly-fern. *Vide* **Dryopteris.**
Horsetail. *Vide* **Equisetum.**
Hymenomycetes, 50. — Literature of, 55.
Hymenophyllaceæ, 11, 26, 79.

I

Imbricate (Lat. *imbrex*, a [hollow tile), breaking joints like slates or shingles.
Indusium (plu. *indusia*) (Lat. *induere*, to clothe), the membranous covering of the sporangia in many species of ferns.
Inferior, attached below; said of an indusium below the sporangia as in *Woodsia*.
Intramarginal (Lat. *intra*, within, and *margo*, a border), near the margin.
Involucre (Lat. *involvere*, to wrap up), the indusium.
Isoetaceæ, 142; also 37.—Literature of, 38.
Isoetes, 142; also 37, 38, 69.
Isosporous (Gr. ἴσος, equal, and σπορός, a seed), producing spores of one kind.

L

Lace-fern. *Vide* **Cheilanthes.**
Lacinia (plu. *laciniæ*) (Lat. the lappet of a garment), a long narrow lobe.
Lady-fern. *Vide* **Asplenium.**
Lanceolate (Lat. *lanceola*, a little spear), lance-shaped.
Lepidodendraceæ, 69.
Lichenes, 52.—Literature of, 60.
Ligula (Lat. a strap), a triangular or somewhat elongate stipule-like organ of the leaf in *Isoëtes*, situated above the sporangium.
Linear (Lat. *linea*, a line), long and narrow.
Linnæus, definition of species, 43.—System of, 47.
Lip-fern. *Vide* **Cheilanthes.**
Lobule (Lat. *lobulus*, diminutive of *lobus*, a lobe), a small lobe.
Lomaria, 101; also 2, 14, 77.
Lunate (Lat. *luna*, the moon), crescent-shaped.
Lunulate (Lat. *lunula*, diminutive of *luna*, the moon), smaller than lunate.
Lycopodiaceæ, 135; also 34.—Literature of, 37.
Lycopodium, 135; also 34, 35, 36, 69.
Lygodium, 122; also 4, 17, 66, 79.

M

Macro- (Gr. μακρός, long), (as a prefix) large or long.
Maidenhair. *Vide* **Adiantum.**
Male-fern. *Vide* **Aspidium.**
Marattiaceæ, 45.
Marsilia, 125; also 39, 40, 69.
Marsiliaceæ, 125; also 39.—Literature of, 40.

Mesozoic Age, Pteridophytes of, 66.
Micro (Gr. μικρός, small), (as a prefix) small.
Midvein, the middle or main vein of a frond, pinna, pinnule, or segment.
Mimicry, 3.
Monœcious (Gr. μόνος, single, and οἶκος, house), bearing the male and female organs on different parts of the same plant.
Moonwort. *Vide* **Botrychium.**
Mucronate (Lat. *mucro*, a sharp point), having the midvein prolonged beyond the pinnule, forming a sharp point.
Musci (mosses), 52.—Literature of, 61.
Myxomycetes, 51. — Literature of, 57.

N

Nephrodium. *V.* **Dryopteris.**
Nephrolepis, 117; also 5, 16, 78.
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Notholæna, 85; also 6, 9, 13, 76.

O

Oak-fern. *Vide* **Phegopteris.**
Oblong, from two to four times as long as broad.
Obovate (Lat. *ob*, reversed, and *ovum*, an egg), inverted ovate.
Onoclea, 119; also 2, 3, 5, 10, 17, 66, 72, 78.
Oöphyta (Gr. ὠόν, an egg (spore), and φυτόν, plant).
Oösphere (Gr. ὠόν, an egg), the female element of Pteridophytes.
Oöspore (Gr. ὠόν, an egg, and σπορός, a seed), the fertilized oösphere.
Ophioglossaceæ, 128; also 28.—Literature of, 31.
Ophioglossum, 128; also 6, 29, 30.
Orbicular (Lat. *orbiculus*, diminutive of *orbis*, a circle), circular.
Orders, 45.
Osmunda, 124; also 2, 3, 4, 5, 6, 18, 19, 80.
Osmundaceæ, 12, 79.
Ostrich-fern. *Vide* **Onoclea.**
Ovate (Lat. *ovum*, an egg), having the form of the longitudinal plane of an egg with the base downward.
Ovoid (Lat. *ovum*, an egg, and Gr. εἶδος, form), having the form of an egg.

P

Paleaceous (Lat. *palea*, chaff), clothed with chaffy hairs.
Palmate (Lat. *palma*, the hand), with the divisions spreading from the end of the stalk like the fingers of the hand.
Panicle (Lat. *panicula*, a tuft on plants), an open cluster, consisting of more or less branching stems bearing fruit.
Papillose (Lat. *papilla*, a nipple), bearing minute nipple-like projections.
Papyraceous (Lat. *papyrus*, paper reed), having the texture of paper.
Pedicel (Lat. *pediculus*, diminutive of *pes*, foot), the stalk of a sporangium.
Pellæa, 97; also 2, 3, 6, 14, 77.
Peltate (Lat. *pelta*, a small shield), shield-shape; said of an indusium borne on a stalk attached at its centre.
Pentagonal (Gr. πέντε, five, and γωνία, angle), having five sides.
Perisporiaceæ, 52.—Literature of, 60.
Peronosporeæ, 51.—Literature of, 57.
Petiole (Lat. *petiolus*, diminutive of *pes*, foot), the stalk of a pinna or pinnule.
Phegopteris, 108; also 5, 9, 16, 27, 78.
Pilose (Lat. *pilus*, hairy), covered with soft hairs.
Pilularia, 126; also 39, 69.
Pinna (Lat. a feather), the primary division of a compound frond.
Pinnate (Lat. *pinna*, a feather), having the divisions of the frond arranged on the two sides of a common rachis.
Pinnatifid (Lat. *pinna*, a feather

and *findere*, to cleave), having the sides of the frond, pinna, or pinnule cut half-way or more to the midvein.

Pinnule (Lat. *pinnula*, diminutive of *pinna*, a feather), the secondary division of a frond twice or more compound.

Polypodiaceæ, 11, 76.

Polypodieæ, 76.

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Pro-embryo, the thread-like prolongation between the germinating spore and the prothallium.

Prothallium (Lat. *pro*, previous to, and *thallus*, a young shoot), the sexual generation of a fern, 20.

Protophyta (Gr. πρῶτος, first, simplest, and φυτόν, a plant), 50.

Psilotum, 139; also 35.

Pterideæ, 76.

Pteridoid (Gr. πτέρις, fern, and εἶδος, form), fern-like in appearance.

Pteridoid Phase, 22.

Pteridophytes (Gr. πτέρις, fern, and φυτόν, a plant), 52, 75.

Pteris, 90; also 5, 13, 68, 77.

Pyrenomycetes, 52.—Literature of, 60.

Q

Quadri- (Lat. *quattuor*, four), (as a prefix) four, fourfold.

R

Rachis (Gr. ῥάχις, the spine), the continuation of the stipe through a compound frond.

Raphe (Gr. ῥαφή, a seam or suture), the ridge which connects the sporocarp with its stem in *Marsilia*.

Rattlesnake-fern. *Vide* **Botrychium.**

Receptacle (Lat. *recipere*, to receive), the part to which the sporangia are attached, especially in the HYMENOPHYLLACEÆ.

Reniform (Lat. *renes*, the kidneys), kidney-shaped.

Resurrection-plant. *Vide* **Selaginella.**

Revolute (Lat. *revolvere*, to roll back), rolled backward; said of the margin of fronds.

Rhizocarps. *Vide* **Marsilia.**

Rhomboidal (Gr. ῥόμβος, a rhomb, and εἶδος, form), approaching a rhomb in shape.

Rock-brake. *Vide* **Cryptogramme.**

Rock-moss. *Vide* **Selaginella.**

Roots, 25.

Rootstock, an underground stem 8.

S

Salvinia, 127; also 39, 40.

Salviniaceæ, 127; also 39.—Literature of, 40.

Scandent (Lat. *scandere*, to climb), climbing.

Schizæa, 123; also 11, 18, 79.

Schizæaceæ, 11, 79.

Schizomycetes, 51.—Literature of, 57.

Scolopendrium, 107; also 3, 6, 15, 19, 26, 78.

Scouring-rush. *Vide* **Equisetum.**

Segment, one of the divisions of a pinnatifid frond.

Selaginella, 140; also 34, 35, 36, 69.

Selaginellaceæ, 140; also 34.—Literature of, 37

Sensitive-fern. *Vide* **Onoclea.**

Serrate (Lat. *serra*, a saw), having the margin cut into teeth pointing forward.

Sessile (Lat. *sedere*, to sit), without a stalk or petiole.

Setiform (Lat. *seta*, a bristle, and *forma*, form), bristle-like.

Shield-fern. *V.* **Dryopteris.**

Sigillariaceæ, 67.

Sinuate (Lat. *sinus*, a bending), having the margin alternately bending inward and outward.

Sinus (Lat. a bending), a recess or bay; the re-entering space between two lobes.

Sorus (plu. *sori*) (Gr. σωρός, a heap or cluster), the clusters of fruit in the POLYPODIACEÆ.

Spatulate (Lat. *spatula*, a little spoon), shaped like a spatula.

Species, 43.—How to determine, 68.

Specific Names, 41.

Spermaphytes (Gr. σπέρμα, a seed, and φυτόν, a plant), 10, 20, 50.—Literature of, 59.

Spinulose (Lat. *spina*, a thorn), thorny.

Spleenwort. *Vide* **Asplenium.**

Sporangium (plu. *sporangia*) (Gr. σπορός, a seed, and ἄγγος, a vessel), the case or capsule enclosing the spores, 10.

Spore (Gr. σπορός, a seed), the fruit of the higher cryptogams, produced asexually, 10, 18.

Sporocarp (Gr. σπορός, seed, and καρπός, fruit), the fruit-bearing receptacle in *Marsilia*, etc.

Squamous (Lat. *squama*, a scale), with appressed scales.

Stellate (Lat. *stella*, a star), star-shaped.

Stipe (Lat. *stipes*, a stock), the stem of a frond, 8, 25.

Stoma (plu. *stomata*) (Gr. a mouth), the breathing pores of plants, 26, 33.

Stramineous (Lat. *stramen*, straw), straw-colored.

Struthiopteris. *Vide* **Onoclea.**

Sub- (as a prefix), about, nearly, somewhat.

Sub-Orders, 44.

Subulate (Lat. *subula*, a shoemaker's awl), awl-shaped.

Superior, higher, applied to indusia that are attached above the sorus as in *Dryopteris*.

Synonymy, 43.

T

Tænitis, 88; also 6, 13, 76.

Ternate (Lat. *terni*, three each), branching into three nearly equal divisions.

Tertiary Age, Pteridophytes of, 66.

Thallophytes (Gr. θαλλός, a young shoot, and φυτόν, a plant), a group of plants including the lichens, fungi, and algæ, 50.

Thalloid (Gr. θαλλός, a young shoot, and εἶδος, form), having the form of a thallus, *i.e.*, no leafy axis.

Thalloid Phase, 19.

Tissues, 24.

Tissue Systems, 25.

Tomentose (Lat. *tomentum*, a stuffing of wool), covered with matted woolly hairs.

Tomentum (Lat. a stuffing of wool), the dense matted woolly hair found on some ferns as many species of *Cheilanthes*.

Tri- (Lat. *tris*, three), (as a prefix) three, thrice.

Tribes, 44.

Trichomanes, 122; also 6, 11, 17, 79.

Trichomes (Gr. θρίξ, hair), hairs, variously modified as scales, indusia, sporangia, etc., produced from the epidermal cells, 26.

Triquetrous (Lat. *triquetrus*), three-angled.

Truncate (Lat. *truncare*, to cut short), cut off abruptly.

Tufted, growing in clusters.

U

Undulate (Lat. *undula*, a little wave), wavy-margined.

Uredineæ, 51.—Literature of, 58.

V

Vallecuia (plu. *valleculæ*), the grooves on the stems of *Equisetum*.

Variation among species, 2.

Varieties, 44.

Vascular (Lat. *vasculum*, diminutive of *vas*, a vessel), containing vessels, as ducts, etc.

Velum (Lat. a *curtain*), the membranous margin of the fovea in *Isoëtes*.

Venation (Lat. *vena*, a vein), the veining of the frond, 10.

Vernation (Lat. *ver*, spring), the arrangement of the leaves or fronds in the bud, 29.
Vittaria, 89; also 6, 13, 76.
Vittarieæ, 76.

W

Walking-leaf. *Vide* **Camptosorus.**
Water-fern. *Vide* **Marsilia.**
Wood-fern. *Vide* **Dryopteris.**
Woodsia, 119; also 6, 11, 17, 43, 79.
Woodwardia, 102; also 2, 5, 10, 15, 68, 77.

Z

Zygophyta (Gr. ζυγόν, a yoke, and φυτόν, a plant).

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